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NEW OR LITTLE KNOWN NORTH AMERICAN TREES. II.

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Gleditsia Texana, n. sp.—Unarmed. Leaves puberulous, or tomentose toward the base of the slender rachis, ultimately becoming nearly glabrous, 12 to 22-foliolate; leaflets oblong-ovate, often somewhat falcate, rounded or acute, and apiculate at the apex, obliquely rounded at the base, obscurely crenulate-serrate, short-petiolulate, thick and firm, dark green and lustrous on the upper surface, pale on the lower surface, ½ to 1 in. long. Staminate flowers orange-yellow, in slender racemes 3 to 4 in. long; calyx-lobes ovate, acute, villous, rather shorter than the petals; stamens exserted. Pistillate flowers unknown. Legume straight, compressed, without pulp, rounded or short-pointed at the apex, abruptly rounded at the broad base, thin-walled, dark chestnut-brown, puberulous, only slighly thickened on the margins, many-seeded, 4 to 5 in. long and 1 in. wide. Seeds oval, compressed, dark chestnut-brown and lustrous, nearly ½ in. long.

A tree 100 to 120 feet in height, with a trunk rarely more than 2½ feet in diameter covered with pale smooth bark, and upright slightly spreading branches. Flowers at the end of April. Fruit ripens and falls late in the autumn.

High rather dry bottom-lands of the Brazos river near Brazoria, Texas, in dense woods composed principally of *Gleditsia triacanthos*, *Platanus occidentalis*, and *Populus deltoidea*.

First made known from legumes picked up from the ground several years ago by Mr. N. S. Plank, and later by collections made by Mr. B. F. Bush in 1899 and 1900.

Gleditsia Texana is an interesting addition to the North American silva. From *Gleditsia triacanthos*, which it resembles in foliage and in the staminate flowers, it is distinguished by its spineless branches and smoother pale bark. From all other species of the genus it differs in the legume. This resembles those of the many-seeded species, of which *Gleditsia triacanthos* is the type, in its general form and color, and in its numerous seeds. It differs from them in its much smaller size, thin compressed walls with thinner margins, and in the absence of the sweet pulp which surrounds their thicker lighter-colored seeds. It differs in form from the compressed pulpless legume of *Gleditsia aquatica*, and in its more numerous seeds. Like the legume of that species, the legume is frequently seedless.

Known only in a single grove in a comparatively small number of individuals, and sharing something of the character of each of the other American species which both grow near it, the hypothesis of a natural hybrid between those species might be considered, were it not for the fact that the fruit of *Gleditsia triacanthos* is nearly half-grown in this region before the flowers of *Gleditsia Texana* open, while the flowers of *Gleditsia aquatica* do not open until ten or twelve days after those of *Gleditsia Texana* have fallen.

Crataegus Engelmanni, n. sp.— Leaves broadly obovate or rarely elliptical, rounded and often short-pointed at the apex, gradually narrowed below into short glandular pilose petioles, coarsely glandular-serrate with incurved teeth usually only above the middle and generally only at the apex, coriaceous, dark green, lustrous and roughened on the upper surface with short rigid pale hairs, pale on the lower surface, pilose above and below on the slender midribs and on the thin obscure primary veins and veinlets, 1 to 1½ in. long and ½ to 1 in. broad; stipules linear-lanceolate, light red, ⅓ in. long, caducous. Flowers ¾ in. in diameter, in 8 to 12-flowered wide slender-branched cymes thickly coated with long pale hairs; bracts linear-lanceolate, tomentose or villous, often ½ in. long; calyx tomentose, villous or nearly glabrous, the lobes narrow, acuminate, entire, glabrous on the outer surface and usually more or less pubescent on the inner surface, reflexed after anthesis, often deciduous before the ripening of the fruit; stamens ten; filaments slender;

anthers small, rose-color; styles two or three. Fruit globose, about ⅓ in. in diameter, bright orange-red with a yellow cheek and thin dry green flesh; tube of the calyx prominent, the cavity broad in proportion to the size of the fruit, shallow; nutlets two or three, thick, prominently ribbed on the back with high rounded ridges, ¼ in. long.

A tree from 15 to 20 feet in height with a trunk 5 to 6 inches in diameter covered with dark brown scaly bark, wide-spreading usually horizontal branches forming a low flat-topped or a rounded head, and slightly zigzag branchlets marked with large scattered white lenticels, at first clothed with pale hairs, becoming nearly glabrous and reddish-brown during the first season and lighter-colored and gray, or gray tinged with red during their second year, and armed with remote slender straight or slightly curved chestnut-brown spines 1½ to 2½ in. long. Flowers from the end of April (Augusta, Ga.) to the end of May (Missouri). Fruit ripens early in November.

Dry hillsides and slopes, often on limestone; less frequently along the low margins of meadows and roadsides. Kimmswick, Missouri, *Dr. George Engelmann*, May 1860; Pacific, Missouri, *George W. Letterman*, 1881; southern Missouri, *B. F. Bush* (nos. 86 and 19), 1898, 1899; West Nashville, Tennessee, *T. G. Harbison*, May 1899; Tuscaloosa, Alabama, *T. G. Harbison*, May 1899; Gunterville, Alabama, *T. G. Harbison*, June 1899; Rome, Georgia, *C. Boynton*, May 4, 1899; Birmingham, Alabama, *C. Boynton*, January and July 1899; Washington Road near Augusta, *A. Cuthbert* and *C. S. Sargent*, April 1900.

Well distinguished from *Crataegus Crus-galli*, with which for many years it has been confounded, by its smaller thinner leaves roughened above by rigid hairs and pilose on the lower surface, more prominent primary veins and villous or tomentose branchlets and cymes, *Crataegus Crus-galli* in all its forms, as I now understand it, being perfectly glabrous, with veins which, except in the case of leaves on the most vigorous shoots, are usually almost entirely within the parenchyma; by its smaller brighter red and yellow fruit; and by its less numerous and more slender spines.

Crataegus Canbyi, n. sp.—Glabrous. Leaves oblong-oval to ovate or rarely obovate, pointed or occasionally rounded at the

apex, cuneate and entire at the base, coarsely and doubly serrate above the middle with glandular incurved teeth, often more or less deeply lobed on vigorous leading shoots with broad acute lobes, coriaceous, dark green and lustrous above, pale and dull below, 2 to 2½ in. long and 1 to 1½ in. wide, or on leading shoots often 3 to 4 in. long and 2 in. broad, the thick midribs and four or five pairs of remote primary veins raised and conspicuous on the lower surface and impressed on the upper surface; petioles stout, grooved and glandular on the upper side with scattered dark red persistent glands, more or less winged above by the decurrent base of the leaf-blades, red below the middle, ½ to ¾ in. long; stipules oblong-obovate to linear-lanceolate, glandular-serrate, ½ in. long. Flowers ⅝ in. in diameter, in loose many-flowered long-branched compound cymes; calyx-lobes narrow, acuminate, serrate with slender teeth tipped with small red glands, nearly entire, reflexed and closely appressed on the fruit, often deciduous before maturity; stamens ten or rarely twelve or thirteen; filaments slender, elongated; anthers small, rose-color; styles three to five. Fruits oblong to subglobose, full and rounded at the ends, depressed at the insertion of the stalks, flesh red, thick, juicy, and succulent, ½ to ⅝ in. long, drooping on the slender elongated peduncles, lustrous dark crimson, punctate with occasional large pale dots; calyx cavity deep and narrow; nutlets three to five, ¼ in. long, light chestnut-brown, prominently ridged on the back with broad rounded ridges.

A bushy much-branched tree 20 to 25 feet in height with a short stout trunk often a foot in diameter covered with dark brown scaly bark; branches stout, erect, wide-spreading, at first dark green and marked with numerous pale raised lenticels, slightly zigzag, soon becoming light orange-brown and lustrous, gray during their second year, and armed with few stout chestnut brown spines varying from ¾ to 1½ in. in length. Flowers the middle of May; the fruit ripens early in October and falls in early winter.

Hedges and thickets near Wilmington, Delaware; Pennsylvania, meadows of Tohickon Creek, Quakertown, *C. D. Fretz*,

1899 and 1900; Tinicum island, Delaware county, *B. H. Smith*, 1900.

To be distinguished from the related *Crataegus Crus-galli* by its oblong usually pointed leaves with veins raised and prominent on the lower surface, by its short infrequent spines, by the habitual appearance of the flowers ten days before those of that species open in the same region, and by the red juicy flesh of the fruit. First noticed in October 1898, by Mr. W. N. Canby of Wilmington, Delaware, who permits the association of his name with this handsome tree.

Crataegus Peoriensis, n. sp.—Leaves obovate, short-pointed or occasionally rounded and sometimes slightly irregularly lobed at the broad apex, gradually narrowed below, sharply and often doubly glandular-serrate usually only above the middle, glabrous with the exception of a few scattered pale hairs near the base of the upper surface of the midribs, thick and firm, with four or five pairs of thin primary veins raised and conspicuous below, deeply impressed above and running very obliquely from the slender midrib to the end of the leaf, dark green and very lustrous on the upper surface, pale on the lower surface, bright bronze color as they unfold, ½ to 2 in. long, ¾ to 1 in. wide, and on vigorous leading shoots frequently a third larger and occasionally laterally lobed; petioles broad, deeply grooved, more or less winged and slightly glandular above the middle, and covered early in the season with short white scattered hairs; stipules glandular, linear-lanceolate, or on vigorous shoots lunate and ½ to 1 in. long. Flowers cup-shaped, ½ in. in diameter when fully expanded, in broad loose slender-stemmed many-flowered corymbs, their bracts and bractlets linear, conspicuously glandular, caducous; calyx glabrous, the cup deep and narrow; calyx-lobes narrow, acuminate, entire or irregularly glandular-serrate with minute stalked dark red glands, pubescent below the middle on the upper surface, spreading nearly at right angles to the cup when the flowers open, persistent on the fruit; stamens ten; filaments elongated, slender; anthers small, rose-color; styles usually two or three. Fruit oblong to obovate, full and rounded at the ends, slightly depressed at the insertion of the peduncle, bright scarlet, ½ to ¾ in. long, with thick

nearly white firm flesh; nutlets two, or rarely three, thick, prominently ridged, about ¼ in. long.

A tree 20 or 25 feet in height with a trunk sometimes a foot in diameter covered with dark brown scaly bark, stout spreading branches forming a broad flat-topped head, and slightly zigzag, glabrous branchlets green when they first appear, orange-brown and lustrous during their first season, growing lighter during their second year, and armed with straight or slightly curved very slender dull chestnut-brown spines 2 to 2½ in. long. Flowers from the middle to the end of May. Fruit ripens early in October but when gathered retains its shape and color until December.

In open woods along the moist borders of streams or depressions in the prairie and on hillsides in clay soil. Short and Peoria counties, Illinois, where it was discovered by *Mr. Virginius H. Chase* of Wady Petra, Illinois, September 1897 (nos. 48, 446, 449, 481, 485).

Crataegus pratensis, n. sp.—Leaves obovate-oblong, pointed or rounded at the apex, gradually tapering below and decurrent nearly to the base of the short slender petioles, sharply and often doubly serrate usually only above the middle with teeth tipped with minute dark red caducous glands, more or less deeply divided above into short broad acute lobes, with slender midribs and narrow oblique primary veins deeply impressed on the upper side and raised and prominent below, bright bronze-yellow and coated on both surfaces with short pale hairs when unfolding; at maturity glabrous, thick and firm, dark green and lustrous on the upper surface, pale on the lower surface, ½ to 2 in. long, 1 to 1½ in. broad, and on vigorous shoots often 3 in. long and 2½ in. broad; stipules lunate, stalked, coarsely glandular-serrate, on vigorous shoots often 1 in. in length. Flowers ⅓ in. in diameter, in broad loose thin-branched many-flowered compound pubescent ultimately glabrous cymes; calyx coated on the outer surface with matted white hairs, the cavity deep and narrow; calyx-lobes acute, coarsely glandular-serrate, spreading or more or less reflexed at anthesis, often deciduous

from the fruit; stamens ten; filaments slender, elongated; anthers small, rose color; styles two or three. Fruit globose, pendent on the elongated peduncles, bright scarlet, ⅓ in. in diameter, with thin dry yellow flesh; nutlets usually two or three, broad and thick, full and ridged on the back, about ¼ in. long.

A tree occasionally 20 feet in height, with a trunk 3 to 7 in. in diameter covered with dark brown scaly bark and frequently armed with long slender much-branched ashy gray spines, wide-spreading branches forming a broad round-topped head, slender glabrous branchlets marked with white lenticels, at first green, becoming light chestnut-brown and lustrous during their first summer, and furnished with slender straight or slightly recurved chestnut-brown spines 2 to 2½ in. long. Flowers from the middle to the end of May. Fruit ripens the first of October and falls in November.

Open woods near the banks of small streams in the prairie region of Stark and Peoria counties, Illinois, where it was discovered by *Mr. Virginius H. Chase* in May 1898. Rare and local. Trees which appear to be of the same species were found by *Mr. B. F. Bush* near Swan, Taney county, Missouri, in October 1889; and later by *Professor William Trelease* and myself.

Crataegus submollis, n. sp. (*Crataegus tomentosa* Emerson, Trees Mass. 435. 1846 [not Linnaeus]; ed. 2, 494, *pl.* —. 1875.—*Crataegus coccinea mollis* Brunet, Cat. Vég. Lig. Can. 25. 1867 [in part, not Torrey & Gray]; Watson & Coulter, Gray's Man. ed. 6. 165. 1890 [in part].—*Crataegus subvillosa* Macoun, Cat. Can. Pl. **1**: 147. 1888 [in part, not Torrey].—*Crataegus mollis* Sargent, Silva N. Am. **4**: 99. *pl. 182.* 1892 [in part, not Scheele]; Koehne, Herb. Dendr. 232.—*Crataegus coccinea subvillosa* Lange, Rev. Spec. Gen. Crataegi 31. *fig.* —).—Leaves ovate, acute, cuneate at the base, sharply serrate with gland-tipped teeth, slightly divided above the middle into three or four pairs of acute lobes, membranaceous, pale yellow-green and roughened on the upper surface with short closely appressed rigid hairs, paler and at first coated below with dense hoary tomentum, at maturity puberulous only on the prominent midribs and remote

slightly raised veins, 2½ to 4 in. long and 2 to 2½ in. wide; petioles slender, slightly grooved and glandular on the upper side, winged above by the decurrent bases of the leaves, tomentose, often tinged with red below the middle and 1 to 2 in. long; stipules linear-lanceolate or lunate on vigorous shoots, tomentose, glandular-serrate, ½ to ¾ in. long, caducous. Flowers 1 in. in diameter, in broad many-flowered compound tomentose cymes, their bracts and bractlets glandular-serrate with dark glands; calyx tomentose, its cup deep and broad; calyx-lobes acute from a broad base, tomentose, glandular with small stalked persistent red glands, usually wide-spreading at anthesis and persistent, erect and much enlarged on the fruit; stamens ten; filaments slender; anthers small, pale yellow; styles three to five. Fruit pear-shaped with yellow subacid dry flesh, about ¾ in. long, gracefully drooping on the slender elongated puberulous branches of the cymes, bright orange-red, lustrous, marked with occasional pale lenticels, puberulous toward the base; nutlets usually five, rounded and slightly ridged on the back, a third of an inch long. Flowers from the 20th to the end of May. Fruit ripens and falls from the first to the middle of September.

A tree 25 to 30 feet in height with a trunk occasionally a foot in diameter covered with light brown scaly bark, and wide-spreading branches, or often a tall intricately branched shrub, and with branchlets at first green and coated with hoary tomentum, becoming before midsummer dark orange-brown, and during their second year lustrous and pale gray-green to orange-brown, glabrous and very lustrous, slightly zigzag and armed with slender bright chestnut-brown straight or more or less incurved spines 2½ to 3 in. long.

On rich hillsides, along the margins of roads, and sometimes in low moist soil, from the neighborhood of Montreal, *J. G. Jack*, 1899, to Orono and Dover, Maine, *M. L. Fernald*, May 1887, and Aguust 1896; Gerrish island, Maine, *J. G. Jack*, September 1899; and to Jamaica Plain and Milton, Massachusetts.

Confounded by me in the fourth volume of *The Silva of North America*, where it is well figured, with *Crataegus mollis* of Scheele, a common tree

from Michigan to Nebraska and Missouri. *Crataegus submollis* differs from that species in its smaller and less deeply lobed cuneate leaves, which are not truncate or cordate even on vigorous leading shoots; in its ten, not twenty, stamens; smaller, less downy fruit on much longer, more slender and drooping peduncles; in its more zigzag orange-colored branchlets, those of *Crataegus mollis* being of a bright chestnut-brown color during the first summer; longer and much more numerous spines; and in its smaller size.

Crataegus dilatata, n. sp.— Leaves ovate from a broad, truncate, cordate, or slightly rounded base, coarsely irregular glandular-serrate, unequally lobed usually with two or three pairs of acute lateral lobes, membranaceous, with slender midribs and four or five pairs of thin primary veins, when the flowers open roughened on the upper surface with short ridged white hairs, light yellow-green, and conspicuously plicate, at maturity dark green, 2 to 2½ in. long, usually as wide as long, and on vigorous leading shoots often 4 to 4½ in. long and usually rather broader than long; petioles slender, terete, glandular, at first more or less villous but soon glabrous, 1 to 1½ in. long, dark red toward the base; stipules linear-lanceolate and on vigorous shoots lunate and foliaceous, glandular with dark red glands, ½ in. long, caducous. Flowers 1 to 1⅛ in. in diameter when expanded, in broad, open, nearly glabrous, villous or tomentose compound cymes, the bracts and bractlets, like the bud-scales, glandular with stalked red glands; calyx villous with soft white deciduous hairs, the cup broad and shallow; calyx-lobes broad, acuminate, coarsely glandular-serrate, much enlarged and spreading on the fruit, and bright red on the upper surface below the middle; stamens 20; filaments slender, elongated; anthers large, rose color; styles usually five, surrounded at the base by small tufts of white hairs. Fruit subglobose with sweet, yellow, thick flesh, ¾ in. in diameter, bright scarlet, punctuate with minute dark spots; nutlets five, comparatively small, prominently ridged on the back, about ¼ in. long.

A tree sometimes 20 feet in height, with a tall straight trunk, wide-spreading branches forming a broad round head, or bushy with numerous spreading stems and slender, glabrous, slightly zigzag branchlets marked with large pale lenticels, at first

dark green tinged with red, becoming light chestnut-brown and very lustrous during their first season, dark dull gray in their second year, and armed with stout straight chestnut-brown spines 1 to 2 in. long, or sometimes nearly spineless. Flowers about May 20. Fruit ripens and falls early in September.

Rich hillsides and borders of salt marshes. Revere, Massachusetts, *C. E. Faxon*, May 1884; Somerset, Massachusetts, *Miss L. H. Handy*, May 1899; Ipswich, Massachusetts, *John Robinson*, May 1900; Tiverton, Rhode Island, *C. S. Sargent*, August 1900; Middlebury, Vermont, *Ezra Brainard*, 1900.

It is possible that this is one of the plants cultivated in Europe as *Crataegus coccinea*, but I have not been able to find any trace of it as a garden plant.

CRATAEGUS HOLMESIANA Ashe, Jour. Elisha Mitchell Sci. Soc. **16**[2]: 78. 1900.—Leaves ovate, pointed, rounded, cuneate or on vigorous leading shoots sometimes truncate or cordate at the base, sharply and often irregularly doubly serrate with sharp teeth tipped at first with prominent dark red caducous glands, usually slightly lobed with from three to five pairs of acute lateral lobes, membranaceous, pale yellow-green above, pale and glabrous below, scabrous on the upper surface with short rigid white hairs when the flowers open, at maturity becoming thick, firm, and nearly smooth, 2 to 3 in. long and 2 to 2½ in. wide, with prominent midribs and five or six pairs of stout primary veins deeply impressed above; petioles slender, terete, slightly grooved and glandular on the upper surface with persistent dark glands, and 1 to 1½ in. long; stipules lunate, glandular-serrate, small, caducous. Flowers cup-shaped, ¾ in. in diameter when fully expanded, in loose many-flowered compound glabrous cymes on slender elongated pedicels; calyx narrow, glabrous, tinged with red, its cup broad and shallow; calyx-lobes acute, glandular-serrate or rarely nearly entire, persistent and erect on the fruit; stamens five or occasionally six, seven, or eight; filaments stout, spreading; anthers large, dark purple-red; styles usually three. Fruit pendulous, oblong, crowned with the erect conspicuous calyx-lobes, crimson,

lustrous, ½ to ¾ in. long, with thin dry yellow flesh of disagreeable flavor; nutlets prominently ribbed, light chestnut-brown, about ¼ in. long.

A tree occasionally 30 feet in height with a well developed trunk 12 to 15 inches in diameter, covered with pale or nearly white scaly bark, stout upright branches forming an open irregular or more rarely a broad compact head, stout chestnut-brown branchlets and straight usually infrequent spines 1½ to 2 in. long. Flowers from the 5th to the middle of May. Fruit ripens and falls early in September.

From the Province of Quebec, *J. G. Jack*, and Ontario, *D. W. Beadle*, to Maine, Gardner, *Alice M. Richards*, Ellsworth, *Mrs. M. A. Clarke*, North Berwick, *Mrs. John Parlin*, Acworth, *R. Hoffman;* New Hampshire, Holderness, *C. E.* and *W. Faxon*, Haverhill, *E. Faxon*, Troy, *Rand* and *Robinson;* Vermont, Charlotte, *F. H. Horsford*, Ferrisburg and West Addison, *Ezra Brainard*, Bennington, Rutland, North Pownal, and Fairhaven, *W. W. Eggleston*, Rutland, *C. S. Sargent;* Massachusetts, Berlin and West Boylston, *J. G. Jack*, South Lancaster, *C. S. Sargent*, Lanesboro, *C. E. Faxon;* New York, "N. N. Y." in Herb. Gray, without date, Fort Crown Point, *Ezra Brainard*, Rochester, *C. C. Laney;* Rhode Island, Tiverton, *Miss Alice Sargent;* and Pennsylvania, Sellersville, *Dr. C. D. Fretz.*

Crataegus Holmesiana inhabits rich moist hillsides and the borders of streams and swamps, and is always easily recognized by the pale bark of the stem, the distinctly yellow color of the leaves, the small cup-shaped flowers with few stamens, and by the large oblong early fruit. It is very abundant in the upland pastures of Worcester county, Massachusetts, and along the banks of Branch creek at Sellersville, Pennsylvania. It is one of the largest species of New England. I have been unable to discover that this handsome tree, which has probably always been confounded with *Crataegus coccinea*, has ever been an inhabitant of gardens, unless the figure of *Crataegus coccinea*, published in 1835 in the *Botanical Magazine* (*pl. 3434*) was intended to represent this species.

CRATAEGUS COCCINEA Linnaeus.—The name *Crataegus coccinea* was first used by Linnaeus in the first edition of *Species Plantarum* 1:476. 1753. His description of this species, "*Crataegus*

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foliis ovatis repando-angulatis serratis glabris," had, however, appeared in 1737 in *Hortus Cliffortianus*. In both works a species of Plukenet (Phyt. Bot. *pl. 46. f. 4*) and a species of Miller (Cat. Pl. Hort. Angl. *pl. 13. f. 1*) were referred by Linnaeus to his *Crataegus coccinea*. Plukenet's plant is preserved in the British Museum. It belongs to the *mollis* group, but the specimen is so meager that I have been unable to identify it. Miller's figure perhaps represents a species of the *mollis* group, but it is certainly not the same plant as the one figured by Plukenet, and I cannot identify it. The only representative of *Crataegus coccinea* in Linnaeus's herbarium, and so labeled by him, is an entirely different plant from either of those represented in Plukenet's or Miller's figures which Linnaeus had referred to his species. Morever, the specimen is not glabrous but villous on the leaves, corymb, and young branches, and the leaves can hardly be described as "*repando-angulatis serratis*." The Linnaean specimen is not dated, and it is therefore possible that it was not from this specimen but from Plunkenet's or Miller's figure that Linnaeus drew his description of *Crataegus coccinea*. There seems in this case, therefore, but one of two methods to follow in considering this name; either the specimen in Linnaeus's herbarium must be ignored, and the name dropped entirely because it was given to a species founded on two distinct plants, neither of which can be satisfactorily determined; or the specimen in the Linnaean herbarium labeled *Crataegus coccinea* by Linnaeus himself must be accepted as the type of this species. In view of the fact that the name *Crataegus coccinea* is one of the best known of the names which have been applied to American species of the genus, and as the plant labeled *Crataegus coccinea* by Linnaeus is now known to be a common and widely distributed species in the north Atlantic coast region, it is perhaps best to consider the specimen in the Linnaean Herbarium as the type of *Crataegus coccinea*, which can be described as follows:

Crataegus coccinea Linnaeus.—Leaves elliptical or on vigorous shoots mostly semiorbicular, acute or acuminate, divided above the middle into numerous acute coarsely glandular-serrate

lobes, cuneate and finely glandular-serrate below the middle and often quite entire toward the base, with slender midribs and remote primary veins arcuate and running to the points of the lobes, at the flowering time membranaceous, coated on the upper surface and along the upper surface of the midribs and veins with short soft white hairs, at maturity thick, coriaceous, dark green and lustrous on the upper surface, paler on the lower surface, glabrous or nearly so, 1½ to 2 in. long and 1 to 1½ in. wide, with slender glandular petioles ¾ to 1 in. long, slightly grooved on the upper surface, often dark red toward the base, and like the young branchlets villous with pale soft hairs; stipules lanceolate to oblanceolate, conspicuously glandular serrate with dark red glands, ½ to ¾ in. long. Flowers ½ to ¾ in. in diameter when fully expanded, in broad many-flowered compound tomentose cymes; bracts and bractlets linear-lanceolate, coarsely glandular-serrate, caducous; calyx tomentose, the lobes lanceolate, glandular-serrate, nearly glabrous or tomentose, persistent, wide-spreading or erect on the fruit, dark red above at the base; stamens ten; anthers yellow; styles three or four. Fruit subglobose, occasionally rather longer than broad, dark crimson, marked with scattered dark dots, about ½ in. in diameter, with thin sweet dry yellow flesh; nutlets three or four, about ¼ in. long, conspicuously ridged on the back with high grooved ridges.

A low bushy tree occasionally 20 feet in height with a short trunk 8 to 10 in. in diameter, or more frequently shrubby and forming wide dense thickets, and with stout more or less zigzag branches bright chestnut-brown and lustrous during their first year, ashy gray during their second season and armed with many stout chestnut-brown straight or curved spines 1 to 1½ in. long. Flowers late in May. Fruit ripens and falls toward the end of October usually after the leaves.

Slopes of hills and the high banks of salt marshes usually in rich well-drained soil, Essex county, Massachusetts, *John Robinson*, 1900; Gerrish island, Maine, *J. G. Jack*, 1899–1900; Brunswick, Maine, *Mrs. Kate Furbish*, May 1899; Newfoundland, *A. C. Waghorne*, 1894.

CRATAEGUS COCCINEA **rotundifolia.**—With *Crataegus coccinea* as described above there often grow in the same thickets plants which differ from it only in the less development of the hairs on the leaves, young branches, and corymbs. Some of these plants are entirely glabrous with the exception of a few short hairs on the upper surface of the young leaves, while others show all degrees of variation in the developement of their villous covering. The synonymy of this form, which cannot be considered more than a variety, is as I understand it as follows:

Crataegus rotundifolia Moench, Bäume Weiss. 29. *pl. 1.* 1785.
Mespilus glandulosa Ehrhart, Beitr. **3**: 20. 1788.
Crataegus glandulusa Aiton, Hort. Kew. **2**: 168. 1789.
Crataegus horrida Medicus, Gesch. Bot. 1793.
Mespilus rotundifolia Du Roi, Harbk. Baumz, **2**: 607. 1795.
Crataegus coccinea Lindley, Bot. Reg. **23**: *pl. 1957*. 1837 (not Linnaeus).
Crataegus coccinea macracantha Sargent, Silva N. Am. **4**: 96. 1892, in part, not Lindley.

Crataegus coccinea rotundifolia is one of the commonest New England forms, ranging southward to eastern Pennsylvania, Easton, *T. C. Porter*, 1894, Stroudsburg, *W. M. Canby*, 1900, and Delaware, Fairhurst, *W. M. Canby*, 1900; and westward to the region of the Great Lakes. Its northern and western range, however, is still imperfectly known, as there are evidently some distinct forms of this group which are still confounded with *Crataegus coccinea* and this variety. All the species of the group, which has been curiously overlooked by American botanists, have thick coriaceous dark green and lustrous mature leaves, flowers with ten or nearly twenty stamens and pale yellow anthers, and globose or subglobose scarlet fruit of medium size with three or four nutlets.

Crataegus Jonesae, n. sp. (*Crataegus coccinea macracantha* Rand & Redfield, Fl. Mt. Desert Island 98. 1894, not Dudley).—Leaves elliptical, pointed, cuneate and decurrent at the base, sharply and doubly serrate and usually lobed above the middle with numerous small acute lobes, coriaceous, dark green and lustrous above, pale and puberulous below, especially on the stout midribs and broad remote primary veins, deeply impressed above, 3 to 4 in. long and 2 to 3 in. broad, at first coated above with soft pale caducous hairs and glandular with small dark red deciduous glands on the teeth; petioles stout, more or less

broadly winged above, deeply grooved, villous, tinged with red below the middle, frequently twisted at midsummer, thus bringing the lower surface of the leaf-blades to the light, 1½ to 2 in. long; stipules linear-lanceolate, entire or coarsely glandular-serrate, ½ in. long, dark green fading red. Flowers bad-smelling, 1 in. in diameter when fully expanded, in loose lax compound many-flowered long-branched tomentose cymes; calyx tomentose, the cup broad and shallow; calyx-lobes linear-lanceolate, entire, tomentose, elongated, persistent and closely appressed on the fruit; stamens ten; filaments slender, elongated; anthers large, pale rose-color; styles two or usually three. Fruit pendulous in loose clusters, oblong to oblong-obovate, full and rounded at the base, ¾ to 1 in. long, ¾ in. broad, lustrous, bright carmine red, punctate with few dark spots, flesh thick mealy sweet and yellow; nutlets three or rarely two, thick, dark-colored, conspicuously ridged on the back, about seven-sixteenths of an inch long.

A tree occasionally 20 feet in height with a tall trunk a foot in diameter covered with dark brown scaly bark, or in the immediate vicinity of the sea often shrubby with numerous stout spreading stems forming a broad massive bush, and stout wide-spreading or ascending branches zigzag for several years, dark green, tomentose and marked with numerous dark red oblong lenticels when they appear in the spring, becoming dark orange-color and very lustrous in the first season and light gray during their second year, and armed with straight or occasionally curved spines, 2 to 3 inches in length, dark chestnut-brown and lustrous and usually pointed toward the base of the branch. Flowers in early June. Fruit ripens and falls early in October.

Borders of streams, where it grows to its largest size, and the rocky banks of ocean sounds and bays. Now known only in southeastern Maine, where it is distributed from the valley of the Penobscot river to the island of Mt. Desert. Orono, *M. L. Fernald*, May 27, 1887; Somesville, *Rand & Redfield*, June 1889; Somesville, *E. Faxon*, June 1890; *E. L. Rand*, Birch hill, Mt.

Desert island, June 1890, Northeast harbor and Southwest harbor, September 1899; Castine, *C. E. Faxon*, September 1889; Bar harbor, *Miss B. Jones*, June and September 1899.

It is a pleasure to commemorate in this handsome and distinct tree the name of Miss Beatrix Jones, the distinguished landscape-gardener, who first made it possible for me to understand its characters.

ARNOLD ARBORETUM,
Jamaica Plain, Mass.

ERIOCAULON DECANGULARE L.; AN ANATOMICAL STUDY.

THEO. HOLM.

(WITH FIVE FIGURES)

IN a paper entitled "Structure de la racine et disposition des radicelles dans les Centrolepidées, Eriocaulées, Joncées, Mayacées, et Xyridées,"[1] Van Tieghem arrives at the conclusion that these orders possess the same peculiarity in regard to the structure of pericambium as do the Gramineæ and Cyperaceæ, and in this they appear to differ from the other orders of monocotyledons. His conclusions in regard to the Gramineæ and Cyperaceæ, however, are mostly based on the observations of Johannes Klinge, which are recorded in his excellent work, "Vergleichend histologische Untersuchung der Gramineen- und Cyperaceen-Wurzeln."[2] It is the structure of the pericambium, Van Tieghem's *péricycle*, which exhibits such marked variation as to seem characteristic of certain orders, at least in some of the species, and the variation consists in its continuity or interruption by the proto-hadrome vessels. Some very instructive tables are contained in Klinge's paper, in which the position of these vessels has been given in relation to the pericambium of a number of species of Gramineæ and Cyperaceæ. From these tables it is seen that in some species all the proto-hadrome vessels are within the pericambium, in others only half of them or only a few, while in still others they are all in direct contact with the endodermis, having thus broken through the pericambium. Van Tieghem describes the same variation in Eriocaulaceæ, etc. Representatives of no less than seven orders of monocotyledons thus exhibit this peculiar structure.

The continuity of the pericambial stratum is considered

[1] Jour. de Botanique 1: 305. 1887.

[2] Mém. de l'Acad. Imp. d. sc. d. St. Petersbourg VII. 26: 12. 1879.

normal, its interruption abnormal. So far, botanists have not ventured to consider these two conditions as anything but specific characters, and if they were really constant they would certainly be of some importance; but my observations have lately shown that they are not to be depended upon as constant in all species. For example, in *Carex hispidula*[3] the pericambium may be interrupted either by all the proto-hadrome vessels or by some of them, while in *C. firma* and *C. supina* this tissue is either continuous or interrupted by the majority of these vessels. These variations were noticed in roots of a single individual, and it is very likely that such irregularities are much more common than is supposed, even in spite of an examination of abundant material. In regard to the Eriocaulaceæ, Van Tieghem describes the root-structure of a few species, and calls special attention to the very regular interruption of the pericambium by all the proto-hadrome vessels in *E. decangulare*, *E. septangulare*, *E. Dregei*, *E. Sellowianum*, and *E. Paraguayense;* while in *E. atratum* and *E. Kunthii* only some of these vessels have broken through the pericambium. Moreover, this author attributes six or eight rays of hadrome to *E. decangulare*, and states that each ray is composed of two vessels, one bordering on endodermis, the other on the central vessel, but separated from it by a layer of conjunctive tissue. Besides Eriocaulon Van Tieghem has described Lachnocaulon,[4] Paepalanthus, and Philodice.

Having observed the irregular disposition of the proto-hadrome in some species of Carex, it seemed well to investigate the matter further, and I have examined the root structure of various other genera, and among them Eriocaulon; and since *E. decangulare* L. exhibits a similar and even more striking variation in its root structure, it was thought worth while to present

[3] On a collection of Carices from Alaska, with remarks upon the affinities of *Carex circinata* and *C. leiocarpa* C. A. MEY. Am. Jour. Sci. IV. **10**: 279. 1900.

[4] Judging from Van Tieghem's description of the root structure in *Lachnocaulon Michauxii* Kth., it appears that his specimens did not belong to this genus, but to Paepalanthus, and evidently *P. flavidulus* Kth. On the other hand, the structure of our North American *Lachnocaulon Michauxii* resembles that which Van Tieghem has ascribed as peculiar to Paepalanthus.

the results. Furthermore, some notes upon the anatomy of the leaf and stem are appended, for it must be remembered that very little has been published heretofore upon the anatomy of Eriocaulon. As stated above, the root structure has been discussed by Van Tieghem, but only in reference to seven species of the genus; and *E. helichrysoides* is the only one which is treated from a general histological point of view by V. A. Poulsen in his anatomical study of the order.[5] Besides these papers there are some few scattered remarks upon the structure of various organs of the genus in the works of DeBary, Russow, and Schwendener. There is thus only one paper in which a general anatomical treatment of the order has been presented, the work by Poulsen cited above. This author, who has studied fifteen species belonging to nine genera, especially Paepalanthus, all from Brazil, deserves credit for having detected several structural peculiarities; and it is a matter for regret that but one species of the large genus Eriocaulon has been examined.

In the present paper some of the anatomical features of *E. decangulare* will be discussed, and attention will be called to such points as do not harmonize with the conclusions of Poulsen and Van Tieghem in reference to this species and others. The material was collected in sphagnum swamps in the vicinity of Washington, D. C. These swamps are wet during the entire season, so that the plants which were studied were not exposed to any drought during the summer months; furthermore, the plants were almost fully exposed to sunlight. Among the plants associated with Eriocaulon may be mentioned: *Fuirena squarrosa*, *Scleria reticulata*, *Eleocharis tuberculosa*, *Rhynchospora alba*, *R. glomerata*, *R. cephalantha*, *Xyris flexuosa*, *Pogonia ophioglossoides*, *Drosera rotundifolia*, *Utricularia subulata*, *Rhexia Mariana*, and *Asclepias rubra*.

THE ROOT.

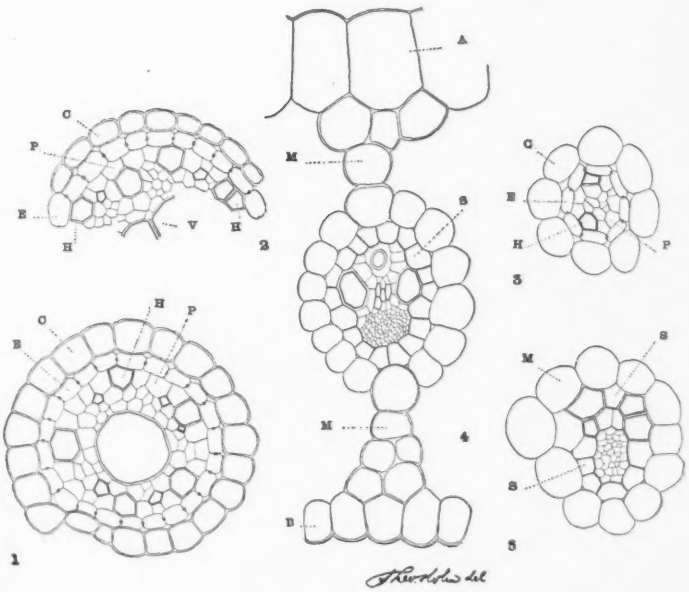
The roots of *E. decangulare* studied were all secondary, being developed from the rhizome. Two kinds may be distinguished: some that are quite thick, white, mostly unbranched, and with

[5] Anatomiske Studier over Eriocaulaceerne. Thesis, Copenhagen. 1888.

few root hairs; and others that are less white, somewhat thinner but decidedly longer, with many lateral rootlets, and amply provided with root hairs. No special arrangement of these two forms was noticed, but the thick ones were perhaps the more abundant. Both forms appeared to have developed in the same year, and I was unable to detect any pronounced difference in their internal structure that might warrant any further distinction than the one observed in their external appearance.

The thick white roots show a very weak structure in general, which seems to imply that they are of short duration, and probably do not last beyond one season. The epidermis is very thin walled, and root hairs are present, but rather scarce. The root hairs observed were all single, not in pairs, as Van Tieghem observed in species of Paepalanthus (Lachnocaulon?). Poulsen did not find any root hairs at all in *E. helichrysoides*, the specimens of which had perhaps not been lifted with sufficient care. Within the epidermis is a hypodermis of a single stratum, the cells of which are of the same size as those of the epidermis, and are also thin walled. The cortical parenchyma is quite broad, but almost totally collapsed radially, excepting the innermost stratum which borders on the endodermis, and which is often somewhat thick walled in contrast with the other portion of the cortex. There are thus several very wide lacunes in the cortex, and these contain horizontally placed diaphragms composed of star-shaped, thick walled cells, which contain chlorophyll. The lateral roots do not immediately break through the epidermis, but traverse the cortex for some distance downwards before they penetrate the hypodermis and epidermis. A similar course of the lateral roots was observed by Poulsen in *Carpocephalus caulescens* Kth.

The endodermis (*fig. 1, E*) is usually thin walled, and the spots of Caspary are plainly visible. However, in some roots the cell walls of the endodermis are slightly thickened, especially in the basal portion of the root. The pericambium (*figs. 1, 2, P*) is very thin walled, and consists of a single layer, which in no case was observed to be continuous, although a very large number



FIGS. 1–5. ERIOCAULON DECANGULARE L.

FIG. 1. Transverse section of a thick root: *C*, innermost stratum of cortex; *E*, endodermis: *P*, pericambium; *H*, proto-hadrome vessel; the proto-leptome cells are drawn with heavy lines; the drawing shows five proto-hadrome vessels, all bordering on endodermis, and alternating with five groups of leptome; a large vessel occupies the center of the root. × 495.

FIG. 2. Transverse section of a part of a thick root; letters as above; *V*, the two central vessels; one of the proto-hadrome vessels has not broken through the pericambium. × 495.

FIG. 3. Transverse section of a lateral root; letters as above; there are only two proto-hadrome vessels, both of which border on endodermis. × 495.

FIG. 4. Transverse section through a large mestome bundle from the leaf; *A*, epidermis of upper face; *B*, same of lower surface; *M*, the collenchymatic tissue, which surrounds the mestome bundle completely and extends to the epidermis on both faces of the leaf; *S*, the inner sheath, which forms a closed ring around the leptome and hadrome; in the hadrome is a lacune with a ring vessel. × 320.

FIG. 5. Transverse section of a smaller mestome bundle from the leaf; letters as above; the inner sheath (*S*) is interrupted by the vessels. × 495.

of sections were examined. To examine the position of the proto-hadrome in relation to the pericambium, not only were a number of sections taken from roots of various individuals, but also several roots of the same specimen in their entire length from apex to base. The latter method appears to give the most satisfactory results, and is sufficient to demonstrate that neither the position of the proto-hadrome vessels, nor the number of hadromatic rays or of the individual vessels is to be depended upon as a constant character.

A few examples of these structural irregularities are as follows. One of the thick roots possessed at the base eight rays of proto-hadrome, each consisting of a single vessel, five of which had penetrated the pericambium, thus bordering immediately on endodermis. Nearer the apex of the same root the number of rays decreased from eight to seven and to six, five of which had broken through the pericambium, as in the first case. At the apex itself there were only five rays, all of which were bordering on the endodermis; thus the number of interruptions of the pericambium was five in the entire length of this root. In other roots only five rays were found at the base, four of which had broken through the pericambium; and here also there was a similar decrease in number of rays when approaching the apex, where finally all the proto-hadrome vessels bordered on the endodermis. The number of interruptions may vary in the same root, instead of being five, for instance, throughout the entire root; or there may be roots in which all these vessels border on the endodermis, the most frequent condition (*fig. 1*). Van Tieghem ascribes six to eight hadrome rays to this species, each consisting of two vessels, but such regularity in number was not observed in my material. Not only did the number of rays vary, usually decreasing from base to apex, but five was the most common number, each ray consisting of a single proto-hadrome vessel (*fig. 1, H*) instead of two. The largest number of rays observed was eight, but this number, as well as seven, was rather rare, while six or four was not uncommon. While the proto-hadrome vessels were observed as being mostly one in each ray,

sometimes two, three, or even four together were observed, either in the same radius or side by side. This multiplication of vessels was found in the same root in which the majority of sections showed only a single vessel in each ray.

In considering the pericambium itself another irregularity in respect to the number of cells between each two proto-hadrome vessels was observed. Two may be found in many roots, and is no doubt the commonest number; three cells were found, however, in the same roots, but seldom four or five. The leptome forms groups which are roundish in transverse section, and the proto-leptome is plainly visible. The central portion of the root was constantly found occupied by one or two wide reticulated vessels, mostly surrounded by a thin walled conjunctive tissue.

The thinner secondary roots show much the same structure as described above, but root hairs abound. The innermost stratum of the cortex is sometimes distinctly thick walled, and the endodermis often exhibits a similar thickening of its walls. These roots show the same irregularities in the structure of the pericambium and the hadrome as described above, and there is also a wide central vessel surrounded by a thin walled conjunctive tissue.

The lateral roots exhibit a very simple structure (*fig. 3*). No hypoderm is developed, the cortex bordering immediately on epidermis, and composed of only two or three strata, the innermost of which persists (*fig. 3, C*), while the others sometimes collapse radially. The endodermis (*fig. 3, E*) is very thin walled, the spots being very plainly visible; and the pericambium is interrupted by the two rays of proto-hadrome, which alternate with two minute groups of leptome. No central vessel was observed. The peculiar course of the lateral roots in the cortical parenchyma before they break through the hypoderm and epidermis has been described, and it might be added that root hairs are absent from the enclosed part of these roots, but are developed as soon as the root became free.

The roots of Eriocaulon may well be classified as simply

"nutritive," as has been described by Rimbach,[6] since they possess no pronounced power of resistence, and are not contractile or especially adapted for storage.

THE RHIZOME.

According to Gray's Manual (sixth edition) all our species should be "stemless," but Morong[7] has corrected this and describes for *E. decangulare* a short thick caudex one or two inches in length. This species has a nearly horizontal or ascending rhizome, densely covered by remnants of old leaf bases, with no internodes. The numerous long hairs developed from the epidermis are very characteristic, being pluricellular, the cells in a single row, and the basal cell very short. The cortex is differentiated into two or three subepidermal strata, the cells of which are mostly pentagonal in tranverse section, with distinct but narrow intercellular spaces, and an inner tissue of many layers of nearly roundish thin walled cells containing starch. This portion of the cortex is very open on account of large intercellular spaces, but no lacunes were observed. Within the cortex is an endodermis, the cell walls of which are not thickened and do not show the characteristic spots of Caspary. Nevertheless, the endodermis was readily visible by the peculiar clearness of its cell walls in contrast with the surrounding cortical parenchyma, and by the somewhat irregular shape of the cells. Within the endodermis is a large, solid, fundamental tissue, consisting of somewhat thick walled cells with distinct intercellular spaces, and containing starch. The mestome bundles occur in the cortex and in the fundamental tissue. Those in the latter tissue, being thus within the endodermis, are not arranged in any order, and are mostly bicollateral and perihadromatic, but not always completely so. They are not surrounded by any special sheath, and the vessels are either scalariform and quite narrow or reticulated and wider.

[6] Beiträge zur Physiologie der Wurzeln. Ber. d. deutsch. Bot. Gesell. 17: 18. 1899.

[7] Notes on the North American species of Eriocauleæ. Bull. Torr. Bot. Club 18: 354. 1891.

When the mestome bundles break through the endodermis to the cortical parenchyma, they appear much smaller and are then surrounded by a thin-walled endodermis, showing the same power of resisting concentrated sulfuric acid as does the main endodermis. They are almost regularly arranged in two concentric bands, and are either strictly collateral or more or less bicollateral, in the same manner as those of the fundamental tissue. The general structure of the rhizome, therefore, does not differ from that of other monocotyledonous plants, with the exception of the development of the epidermis into long hairs, which is known in a very few other orders. The mestome bundles of Eriocaulon being collateral or more or less completely perihadromatic do not differ from those of rhizomes of most of the other monocotyledonous orders. Attention may be called, however, to a very peculiar structure which Poulsen discovered in the rhizome and stem of *Actinocephalus polyanthus* Kth. (Eriocaulaceæ), and which may be found in some of the other genera. The mestome bundles exhibit a form very unusual among the phanerogams, in being perileptomatic in the cortex and exohadromatic in the fundamental tissue; in the latter the perihadromatic bundles are surrounded by a tissue which is suggestive of leptome, and around this again is a band of vessels, each mestome bundle consisting thus of a central group of leptome surrounded by two bands of hadrome separated from each other by a band of apparently leptomatic tissue.

THE SCAPE.

The inflorescence, a capitulum, is borne at the apex of a long, slender, solid and twisted scape, which is distinctly furrowed and consists of only one internode with a single leaf, the long tubular sheath of which surrounds the scape to about its middle. In a transverse section of the free part of the scape, there is shown an epidermis of roundish cells, covered by a thin, smooth cuticle. The size of the cells varies somewhat, and the largest are observable in the furrows, where they cover the green cortex. Stomata and hairs are present and exhibit the same

structure as in the leaves, under which they will be described. Underneath the epidermis is either a chlorophyll bearing cortical parenchyma (in the furrows) or a mechanical tissue (in the ridges). The former in our species occurs in nearly rectangular groups in transverse section, separated from one another by the mechanical tissue. There is but one stratum of palisade cells, directly beneath the stomatiferous epidermis; while the other part of the green cortex consists of loosely connected cells of irregular shape and with very wide air spaces. No proper lacunes are developed in the cortex, nor are there any such diaphragms as in the leaves.

The mechanical tissue constitutes quite a prominent portion of the stem section. It is this tissue which forms the eight ridges, and it extends inwards to the mestome bundles, which it surrounds as a closed ring, and also occurs as a few layers on the hadrome side of the mestome bundles. A close examination of this tissue, however, shows that even if it may be designated as "mechanical" throughout, it nevertheless represents two distinct kinds of tissues, collenchymatic and stereomatic, both somewhat modified in our species. The collenchymatic tissue reaches its highest development in the ridges of the scape, just beneath the epidermis. It appears there composed of distinctly thickened cells, but roundish in cross section and with plainly visible intercellular spaces; viewed in longitudinal sections these cells are rectangular and quite long. As mentioned above, this tissue extends inwards between the groups of green cortex to the mestome bundles, and occurs here as a closed ring of two or three strata. I have been unable to discover any distinction between the strata which surround the band of mestome bundles and those which form the ridges. The thickening of the cell walls is of course most pronounced in the ridges, and especially near the epidermis, but if the tissue is followed inwards to the mestome bundles the thickness decreases very gradually, and the shape of the cells remains the same in both longitudinal and transverse sections. The term "collenchymatic," as suggested by Schwendener for this special tissue in

Eriocaulon, seems more suitable than "stereomatic"; moreover, it appears that it attains a still further development in other genera of the order, where it sometimes resembles true collenchyma much more than in our species.

The second form of mechanical tissue in the scape so much resembles stereome in its structure that it may be considered as stereomatic, but not as stereome proper. This tissue is but sparingly developed, and occurs only in one or two strata covering the leptome of the bundles within the collenchymatic ribs, and as a few cells on the hadrome side of these same bundles. The lumen of these stereomatic cells is much narrower than in any portion of the collenchyma; moreover, the cells are longer and the cross walls are almost oblique. In no instance, however, did I observe this stereomatic tissue form a sheath around the mestome bundles; it seems to be restricted to a few strata on either face, separated from one another by the large vessels on the sides of the bundles. The small mestome bundles which are located within the chlorophyll bearing cortex are destitute of such stereomatic support. It would thus appear as if the mestome bundles are merely surrounded by continuous strata of collenchyma which only differs from that in the ridges in being less thick walled; and there is no indication of such structural peculiarities as might lead to a separation of it into two tissues, as a collenchymatic and an endodermal. The cells showed exactly the same shape and size all around the central cylinder, and in no place were the spots of Caspary, or any special arrangement usually noticeable in an endodermis, observed. However, when the sections were placed in concentrated sulfuric acid, a true endodermis became at once plainly visible. The collenchyma was rapidly destroyed, while a continuous ring of a single stratum of cells persisted for some time surrounding the mestome bundles and bordering on the leptome, but separated from it by the few strata of stereomatic tissue. The scape thus possesses an endodermis of the same structure as that observed in the rhizome.

It has been stated already that the mestome bundles occur

of two sizes, both constituting a single band, the larger situated in the same radius as the collenchymatic ridges, the smaller in alternation with them within the cortex. The leptome forms quite a large oval or roundish group in both kinds of bundles, all of which are collateral; and the hadrome is composed of very wide reticulated vessels which form a continuous arch in the smaller bundles, sometimes in the shape of a V. In the larger mestome bundles the arch is less complete, and here a small lacune with remains of an annular vessel was observed. This structure of the mestome bundles suggests what is known among other orders of monocotyledons, especially the larger ones. Finally, the pith, which occupies the inner portion of the central cyclinder, is solid, not hollow, but the cell walls are very thin, and no deposits were observed.

The base and apex of the scape show the same arrangement and relative development of the various tissues, but no stomata or hairs were observed on the part enclosed by the tubular leaf sheath. It might be stated, also, that although the mestome bundles were noticed to be strictly collateral in a large number of sections, one instance was found in which a few (three) narrow scalariform vessels were situated outside the leptome, this mestome bundle being thus approximately perihadromatic. It was only in one bundle, however, and very near the inflorescence. The structure of the bundles, therefore, does not seem to be invariably identical throughout the whole length of the stem. It must be remembered, also, that in the rhizome the bicollateral bundles within the endodermis pass gradually over into collateral when they enter the cortical parenchyma, whence they proceed to the leaves, in which they are constantly and strictly collateral.

THE LEAF.

The proper leaves are linear, nearly flat or with the margins somewhat involute, and have no sheath. They form a dense rosette at the apex of the rhizome, and in their axils the flower bearing scapes develop on very short one leaved shoots, while the terminal bud of the rhizome itself is purely vegetative. In

contrast with the proper leaf, the leaf of the floral shoot has a long tubular sheath and a very short blade, and this leaf is by some authors considered as representing the prophyllum of the floral shoot. No other leaf is developed on this shoot, but its true position in relation to the mother axis cannot be ascertained, since the scape becomes twisted during its growth and forces the leaf away from its natural position. Thus the little blade may sometimes turn to the side or to the front, instead of turning its dorsal face towards the main axis, as is the normal position of such a prophyllum. As will be shown later, the structure of this leaf is very different from that of prophylla as a rule, though some analogous cases do exist in other orders, where a similarly developed leaf unquestionably represents a true prophyllum. Attention might be called especially to the clado-prophyllum in the inflorescence of certain Cyperaceæ, as for example, *Scirpus silvaticus*, *S. polyphyllus*, *Cyperus phymatodes*, *C. strigosus*, and many others. So far, there is no very strong objection to considering the leaf of Eriocaulon as a prophyllum, even if its position cannot be determined accurately. There is no very pronounced difference between these two kinds of leaves, but they will be treated separately in order that the view of their general structure may be made as distinct as possible.

The proper leaf, in sections taken from the middle of the blade, shows a large celled epidermis on both surfaces, especially on the upper. There is a thin, but visible cuticle, which shows minute wrinklings on the lower surface, but is smooth on the upper. None of the epidermal cells are arranged so as to form longitudinal rows of bulliform cells, such as are so well known in many genera of Cyperaceæ and Gramineæ, where they especially abound above the keel of the blade or between some of the larger mestome bundles. The cells in Eriocaulon are very large on the upper face, but decrease very gradually in size from the middle towards the margin, the outermost part of which is composed only of the two strata of epidermis corresponding to the two leaf surfaces. Viewed *en face* the radial cell walls are perfectly straight on both surfaces, and the outer cell wall of

the dorsal epidermis is somewhat thicker than the others. The inner wall may sometimes show a peculiar bend inwards, the lumen of the cell thus becoming diminished, while at the same time a wide air space is formed beneath the cell. This case was noticed only on the lower face of the blade, and Poulsen found a similar structure, but much further developed, in the leaves of Dimeranthus and Actinocephalus. While hairs are present on both faces of the blade, stomata are restricted to the lower surface. The hairs are small and much shorter than those on the rhizome, consisting of but three cells, the terminal one being the longest. They are closely appressed to the leaf blade and point towards its apex. This form of hair was also observed by Poulsen in *E. helichrysoides*, and its early stage of development is represented in his *pl. 5, figs. 2–4*.

The stomata occur only on the lower surface, outside the mesophyll, and possess very narrow guard cells and subsidiary cells, both of which, especially the former, are raised a little above the surrounding epidermis.

The mesophyll in our species constitutes a very uniform structure throughout, and the leaf in this respect may be considered isolateral. There is no continuous layer of palisade cells on the upper face, but the tissue consists of a single stratum, only some of the cells of which represent true palisade. Most of the other cells are roundish and very loosely connected with one another. On the lower face the cells of the mesophyll show a similar roundish form, but the intercellular spaces are not so wide as on the upper face. A like structure is represented by the mesophyll around the mestome bundles, where it is also composed of a single stratum bordering on the mechanical tissue. The inner portion of the mesophyll is broken down into wide lacunes, one between each two mestome bundles, in which are found numerous diaphragms of star shaped, chlorophyll bearing cells, exhibiting much the same structure as those in the root.

Attention has been called, in connection with the stem, to the difficulty in designating the proper term for the mechanical tissue as it is developed in Eriocaulon; and the same is true

in regard to it in the leaf, where there is to be observed collenchyma and another form of tissue which superficially resembles stereome, but which shows such strange occurrence and development that it is not even to be considered as a modification of this tissue. The collenchyma in the leaf is thinner walled than in the stem, and accompanies the mestome bundles mostly as hypodermal groups on both faces. It appears to be more strongly developed on the lower face than on the upper, but each group is composed of only three or four layers of these cells (*fig. 4, M*). Around each mestome bundle is a sheath, which at first glance was considered identical with the parenchyma sheath (*fig. 5, M*), as seen in many genera of other orders. A longitudinal section, however, showed a structure very unlike that of a typical parenchyma sheath. The cells were relatively very long, and I was unable to separate them from the adjoining cells of the collenchyma, inasmuch as they both showed the same rapid dissolution when treated with concentrated sulfuric acid. It is somewhat strange, also, that no trace of this outer sheath was found in the stem, a fact which seems to be in favor of the supposition that it is not identical with a true parenchyma sheath. When such sheaths are developed, they seem to follow the mestome bundles not only in the leaves but also in the stem, at least in those which are in the cortex, but not in the pith.

An examination of one of the large mestome bundles (*fig. 4*) reveals the fact that still another sheath (*S*) occurs within the first. This is distinctly thicker walled than the outer, the cells are very much smaller, and the walls are very bright yellow in contrast with the surrounding collenchyma. In longitudinal section the cells of this inner sheath are quite long, with mostly horizontal cross walls. A study of its occurrence throughout the leaf has assured me that it does not show the same development in all the mestome bundles. In smaller bundles the sheath is a mere arch on the leptome side, while the vessels border immediately on the outer collenchymatic sheath. In the larger mestome bundles there is the same arch on the

leptome side, besides one (*fig. 5, S*), or sometimes two or three cells on the hadrome side, between the large vessels. Selecting one of the largest bundles in the leaf, the sheath appears as a closed continuous sheath (*fig. 4, S*) all around the leptome and hadrome. It seems characteristic of this inner sheath to show interruptions in the small mestome bundles, and to become confined in the leptome alone in the smaller of them. I regret that I was unable to decide whether the inner sheath is also developed in the smallest of the mestome bundles, the anastomoses. The tissues are so little differentiated in these that it seemed impossible to decide whether the sheath was present or not; the outer one, however, was plainly visible. So far there would be no valid objection to considering the inner sheath as identical with a mestome sheath,[8] which, in several Gramineæ, exhibits the same kind of interruptions in the various forms of mestome bundles. However, there are two reasons for feeling uncertain about its identity. It is absent in the mestome bundles of the scape, where two or three strata of stereomatic tissue have taken its place within a true endodermis, and in longitudinal section the cells differ in a marked degree from those of a mestome sheath, being very long, with almost horizontal cross walls. Moreover, the thickening of the inner cell wall does not show the same structure as in typical mestome sheaths, where this wall almost constantly exhibits a conspicuous thickening in contrast to the outer wall. When treated with concentrated sulfuric acid, however, the sheath in Eriocaulon showed the same resistance as in the endodermal sheaths in the mestome bundles in the cortex of the rhizome. If the outer sheath represents a parenchyma sheath, one might feel justified in considering the inner as a somewhat modified mestome sheath; but since it does not seem possible to separate the outer sheath from the collenchyma, I can at present suggest no other term for the inner one than simply a protective sheath.

Poulsen attributes two sheaths to the mestome bundles in the

[8] SCHWENDENER, S.: Die Mestomscheiden der Gramineenblätter. Sitzungsber. K. Acad. Berlin 405. 1890.

leaves of the genera which he examined, and, in accordance with his opinion, the outer sheath would represent true parenchyma, the inner sclerenchyma. He saw, however, that the so-called sclerenchyma does not show the same development in all the bundles, but he makes no allusion to its possible identity with a mestome sheath. The outer sheath is only described as being composed of thin walled cells "stretched longitudinally," which does not seem to indicate that a true parenchyma sheath was observed. The testing of these sheaths with sulfuric acid seems to have been omitted.

The mestome bundles of the leaf are almost parallel from the base to near the apex, where they unite and form an apparently single bundle. When viewed superficially the nerves might appear without anastomoses, since the numerous diaphragms filled with chlorophyll make the inner portion of the leaf very indistinct. When the blade is divided into halves the anastomoses may be seen, not at all infrequent, connecting the larger nerves at more or less acute angles. In this way anastomoses become plainly visible even without any further treatment with potassium hydrate, and they are often seen in transverse sections. It seems very surprising that Poulsen did not notice them in any of the fifteen species which he examined, and that he points out the absence of anastomoses as one of the principal characteristics of the order. It may be that they are not developed in any of these fifteen species, but they are certainly very plainly visible in *E. decangulare*, and I have found them also in *E. gnaphalodes* and in *Lachnocaulon Michauxii*.

The structure of the main nerves is very uniform. None of the mestome bundles near the middle of the blade are of any considerable size when compared with others, and it might be said that the leaf has no midrib. It has already been stated that some of the nerves are smaller than others, and that a corresponding variation in regard to the development of the inner sheath is noticeable. However, the hadrome and leptome are common to all the main nerves, but are naturally larger in the thicker mestome bundles than in the thinner. The leptome

shows the same structure as in other orders, for example Cyperaceæ, Gramineæ, etc. The hadrome shows several relatively wide vessels (reticulated) besides a lacune, in which there occurs a ring vessel. The arrangement of the vessels is the same as in Gramineæ, etc., and in no instance was there seen the V-shaped hadrome as in the scape. The very smallest of the mestome bundles exhibit both leptome and hadrome in two well differentiated groups, and several narrow vessels are developed in them, bordering immediately on the collenchyma, while the leptome has an arch-shaped support of an inner sheath, constantly incomplete in such small bundles.

The base of the leaf differs but slightly in structure from the middle of the blade. The lacunes are wider, the mesophyll is more irregular, and no palisades were observed; furthermore, the inner sheath of the mestome bundles is somewhat more thickened, but shows otherwise the same kind of interruptions in the small bundles. The epidermis does not seem to have become modified in any respect, and both hairs and stomata occur. The structure of the apex, however, is very different. The epidermis is unchanged, but the mesophyll presents a solid palisade tissue in three layers on the lower face, while the upper one consists of more roundish cells with narrow intercellular spaces; the mestome bundles are fused together into one oval group surrounded by a sheath of thin-walled cells, which evidently corresponds to the outer one, the collenchymatic; and it may be added also that in the apex this sheath is not able to resist sulfuric acid. There is thus a single group of mestome in the apex, and the leptome seems much reduced, while the hadrome occupies a broad space and contains many very wide vessels, especially reticulated. This single mestome bundle is not supported by any hypodermal mechanical tissue or by an inner sheath, as farther down the blade.

THE PROPHYLLUM.

The prophyllum consists of a very long tubular sheath and a short free blade, in both of which there is much the same

structure as in the proper leaf. The tubular portion, however possesses an epidermis of several (three) layers on its morphologically ventral face, and this epidermal tissue is homogeneous in structure, the cells being of the same size and shape throughout. The dorsal epidermis consists of only one stratum, and the cells are about the same size as those of the ventral epidermis. The mesophyll is very open on account of wide lacunes, as in the proper leaf. The mechanical tissue is developed further in the prophyllum than in the other leaves in having larger groups on the dorsal face and in being distinctly thick walled, almost like collenchyma. The mestome bundles are surrounded by this tissue, and also by the inner sheath, which is much less differentiated, however, in this leaf, being totally absent in the smallest bundles. Furthermore, a somewhat weaker development of the hadrome and leptome is to be seen in this portion of the prophyllum. It may be stated that the structure of the collenchyma was plainly followed to several of the cells of the outer sheath; thus there seems little doubt that this sheath actually represents a part of the mechanical tissue itself, instead of being a specially developed parenchyma sheath.

The little blade resembles very much that of the proper leaf, in regard to the epidermis with its hairs and stomata, and the mesophyll with its lacunes; while the collenchyma is separated from the dorsal epidermis by strata of small palisade cells. There is the same distinct thickening of the collenchyma, and very plainly so where it surrounds the nerves; the inner sheath is but very incompletely developed in this portion of the leaf. The mestome bundles are almost orbicular in transverse section, and exhibit the same difference in relative size as described above; and finally anastomoses more frequently occur in the prophyllum from apex to base. Thus the inner sheath is present also in the mestome bundles of the prophyllum, though less completely developed; and the same result was obtained as before when treating the sections with concentrated sulfuric acid, that is, the outer sheath dissolved at once, together with the adjoining cells of the collenchyma, from which it must be

considered as inseparable, while the inner sheath showed some resistance wherever it occurred.

CONCLUSIONS.

In comparing the general structure of *E. decangulare* with that of *E. helichrysoides*, as described by Poulsen, there seem to be certain peculiarities in common which may be characteristic of the order, inasmuch as they have also been observed in some of the other genera. The presence of collenchyma is one of these, although this tissue should not be considered so rare in monocotyledonous orders as Poulsen claims it to be. It is common, for instance, among the Gramineæ, where it is well developed in the nodes; it is also found in the small "pulvini" which occur at the base of the lateral branches in paniculate inflorescences of a number of genera. Moreover, in the Cyperaceæ collenchyma occurs in the basal portion of both rachis and prophyllum in certain species of Cyperus of the subgenera Eucyperus, Diclidium, and Mariscus; besides in such species of Scirpus as possess a large open inflorescence (*S. atrovirens*, *S. polyphyllus*, and others). A still more advanced development of this tissue may be observed in Commelinaceæ, Smilaceæ, and Dioscoreaceæ. It does not seem, therefore, as if this tissue exists only in "a very few monocotyledons." But it seems characteristic of the Eriocaulaceæ examined that the collenchyma, or to be more exact "collenchymatic tissue," occurs as prominent ridges in the stem, that it replaces the stereome in the leaves, and that it surrounds the mestome bundles as a closed sheath. The inner mechanical sheath, noted in the leaves, appears to have several points in common with the mestome sheath of the Gramineæ, yet it does not seem to be identical with this, and perhaps may be characteristic of Eriocaulon. The hairy rhizome constitutes an excellent character of the order, even if a few instances are known in other orders of hairs on underground stems, viz., Corallorhiza, Scheuchzeria, and Mercurialis. Otherwise the structure of Eriocaulon does not differ so very much from that of certain other orders, as Cyperaceæ and Juncaceæ, in which a

similar leaf structure is provided with a uniform large celled epidermis (Kyllingia, Cyperus, Fimbristylis, etc.). Also, the structure of the rhizome and roots is not to be separated from that of a number of Gramineæ, Cyperaceæ, etc. The most peculiar structure is exhibited by the scape, not only in the presence of collenchymatic ridges, but also in the mestome bundles surrounded by a common endodermis.

But neither the order nor even the genus can be characterized especially by absence of anastomoses in the leaves, since both occur in Eriocaulon and Lachnocaulon; and the continuity of interruption of the pericambium by the proto-hadrome vessels in the root is not of any importance as a family character, as it is not constant, at least in *E. decangulare*.

It appears, therefore, as if Eriocaulon and its allies possess some characters in common with other monocotyledonous orders, and a few which seem peculiar to themselves. The singular inflorescence which is unique among the monocotyledons, and the floral structure, together with the peculiar habit of these plants, make them very distinct among the other orders, to none of which they make any special approach, not even in respect to their morphological characters.

BROOKLAND, D. C.

PHYSIOLOGICAL STUDIES WITH REFERENCE TO THE GERMINATION OF CERTAIN FUNGOUS SPORES.

B. M. DUGGAR.

INTRODUCTORY AND HISTORICAL.

THIS study was entered upon with the view of ascertaining somewhat more definitely than previous researches have indicated what may be some of the special factors which influence germination. As particular lines of inquiry the following may be mentioned as suggestive. In how far does there exist in the spores of fungi an essential physiological difference, whereby some may germinate by the mere absorption of water, while others may require for this germination a food supply from without? Where a food supply is required, does germination require a perfect food or a particular food? May a chemical irritant, or poison, which is not primarily a food substance, thus function as a stimulus? Is it possible by mechanical means, or by a change of conditions, to furnish the necessary stimulus for germination? Considering the broad field thus suggested, it has yet been possible to study but a very limited number of fungi. Moreover, there are numerous minor questions which must be considered in a subsidiary way.

Using the term germination in its broadest sense, it may be well at the outset to notice some of the conditions of food supply or stimulation characterizing germination in general. As a rule, the seed of the phanerogam requires for germination only water, along with suitable conditions of temperature and requisite oxygen supply. Not even does the force of imbibition of the seed coats have any special action in inciting to activity the dormant faculties. In about a dozen plants upon which I have experimented, the uninvested embryo, that is, entirely free from integuments or externally stored food material, is capable of manifesting the first stages of germination in distilled water.

A few phanerogams which have become adapted to a peculiar environment may require a stimulus of this environment. Koch[1] and Heinricher[2] have shown that seeds of Orobanchaceæ germinate only with the presence of a host plant. Heinricher found that the seed usually germinates in spring or autumn, in periods of greatest humidity. He states that the germination of the seed is indirectly a partial indicator of the health of the host — a substance excreted by the latter being evidently the source of the stimulus. What may be the nature of this attractive substance has not been determined. On the other hand, seeds of Rhinanthus seem to germinate without such stimulus.

According to Wiesner[3] the seeds of *Viscum album* are known to germinate only in light, and although apparently mature in autumn, they are not to be forced to germination until the following spring. The same was found true of *Loranthus Europaeus;* and, although light is required for germination, the most favorable conditions of the tropical climate of Buitenzorg could not induce this activity without the intervention of the resting period. Wiesner then surmised that the factors concerned are the gradual availability of the reserve food, a phylogenetic light influence, and the effect of the viscous substance of the integuments. If there are other phanerogams growing in peculiar situations for which a particular stimulus is necessary for germination, the matter seems to await study. We cannot appropriately include in this place seeds of some Rosaceae, for example, which germinate better after passing through the digestive tract of birds, or after artificial treatment with acids.

The germination of pollen has been very much studied, and it is surprising that this has yielded so little of special interest relative to particular or peculiar stimuli. It is of special

[1] KOCH, L.: Die Entwickelungsgeschichte der Orobanchen 119. 1887. Heidelberg.

[2] HEINRICHER, E.: Die Keimung von Lathrea. Ber. d. deut. bot. Gesells. **12**: 117–132. 1894.

[3] WIESNER, J.: Vergleichende physiologische Studien über die Keimung europäischer und tropischer Arten von Viscum und Loranthus. Sitzb. d. kaisl. Akad. d. Wissenschaften zu Wien **103**: 423–437. 1894.

significance that the pollen of so many species of plants germinate either in sugar solution or in water. According to Molisch[4] many forms germinate best in about 10 per cent. sugar solution, and concentrations of from 15 to 40 per cent. are often required. This might suggest an osmotic stimulus. Nevertheless, there are many forms germinating well in water, and for other forms perhaps the idea of a special stimulus should be further applied to a study of pollen. Molisch indeed found minute quantities of malic acid a stimulus to the germination of Ericaceae; but, in general, my results indicate that it is only a stronger stimulus than pure water, not equal to sugar, for example.

Lidforss[5] has recently made extensive studies with pollen germination in "pure water," and among many plants whose pollen is so adapted may be mentioned Orchidaceae, Salicaceae, and many Liliaceae, Geraniaceae, etc. Following in the path of still earlier workers along that line, Borodin[6] clearly indicated that light has a stimulating effect for the germination of fern spores. Kny[7] and others further determined the necessity of this factor. Heald[8] has more recently shown that this stimulus may find a substitute in high temperatures; and apparently he has also cleared up some previous inconsistencies. In the same paper, Heald has demonstrated the necessity of light for the germination of moss spores. In a nutrient solution containing peptone or sugar, on the other hand, good germination resulted in darkness; and higher temperatures alone had no stimulating

[4] MOLISCH, H.: Zur Physiologie des Pollens mit besonderer Rücksicht auf die chemotropischen Bewegungen der Pollenschläuche. Sitzb. d. kaisl. Akad. d. Wissenschaften zu Wien **102**[1]: 423–427. 1893.

[5] LIDFORSS, B.: Weitere Beiträge zur Biologie des Pollens. Jahrb. f. wiss. Bot. **32**; 237–312. 1899.

[6] BORODIN, —: Bull. de l'Acad. imp. de St. Petersbourg: 433–440 1867. (ref. Heald, l. c.).

[7] KNY, L.: Beiträge zur Entwickelunsgeschichte der Farnkräuter. Jahr. f. wiss. Bot. **8**: 1–15. 1877.

[8] HEALD, F. DE F.: Gametophytic regeneration exhibited by mosses and conditions for the germination of cryptogam spores. Inaugural-Dissertation. Leipzig, 1897.

influence, as likewise small quantities of poisonous substances. The further interesting fact was disclosed that the effect of light is not one of photosynthesis. Equisetum spores, moreover according to Sadebeck,[9] germinate well either in light or in darkness.

Notwithstanding the excellent culture methods for the fungi, a study of germination in relation to the stimuli involved has been largely a matter of incidental consideration. A study of growth phenomena, thermal limitations of growth, toxic effect, etc., have furnished some data relative to the stimulus of particular substances. It seems, however, that no summation of the results has been made since the work of DeBary.[10]

METHODS.

The most convenient method of observing spore germination is undoubtedly the hanging drop-culture. The principal points to be considered in properly handling the drop-culture, or Van Tieghem cell, where nutrient media are employed, have been recently set forth clearly by Clark.[11] These notes bear repetition to a certain extent. The employment of large rings is desirable, and they should be cemented to the glass slips by a mixture of refined beeswax and pure vaseline. The cover should be cemented to the ring with vaseline. The same character of liquid should be used at the bottom of the cell as employed in the drop.

While the form of cell culture above described is highly accurate for culturable forms in nutrient media, it is by no means accurate in all other cases. When a careful study is to be made of particular stimulants in water, or in a medium not ordinarily causing abundant germination, and the like, recourse should be had to a different method. My experience has been that the

[9] SADEBECK, R.: Ueber die Entwickelungsgeschichte d. Prothallien u. s. w. der Schachtelhalme. Sitzungsber. d. Versammlung deutscher Naturforscher u. Aerzte zur Hamburg, 1876.

[10] DEBARY, A.: Morphologie und Biologie der Pilze, 376–377. 1884.

[11] CLARK, J. F.: Dissociation and toxic effect. Journal of Physical Chemistry 3: 263–316. 1899.

results may be untrustworthy if any volatile or soluble substance besides the medium employed is used in connection with the cultures. As subsequently mentioned, even the purest vaseline may have an effect on sensitive forms. In all cell cultures in which full nutrient media were not employed, I have used a modified method. The cells were used in small Petri dishes. On the bottom of the Petri dish was placed filter paper with holes made for the insertion of the cells, thus securing them against movement. The covers were laid on without vaseline, and only in a few cases with volatile substances was any vaseline placed on the outer rim of the Petri dish. Dishes with ground-glass tops are preferable. All cultures were kept in moist chambers. The one difficulty remains of opening the cultures for examination, but as it is done only once, or at most twice during the continuance of the experiment, it is perhaps a matter of small significance.

All cells, dishes, flasks, etc., used in these experiments were first cleaned with an alkali, then an acid, and finally, after thorough washing in distilled water, steamed for an hour or two before use. Particular care was taken with the covers, which were also boiled in the cleaning materials, and kept soaking either in distilled water, or in some cleaning agent when not in use. Cultures were kept in the warm room at a temperature of about 25° C., this temperature being especially commendable on account of ease of examination at the same temperature.

After considerable experience with vegetable decoctions for the growth of fungi, I have generally adopted a decoction of green string beans or of sugar beets as the best culture medium for most readily culturable fungi. Any absolute standard of strength is impossible, but as a working basis, fifty grams of dry matter for each liter of water has been found convenient; thus for green beans, from an average of analyses, three hundred and ninety-two grams would be required per liter.

The chemicals used have been the purest obtainable; and the sugar was recrystallized by the alcohol method, and subsequently

washed with ether. As a standard nutrient-salt solution the following well-known formula was adopted:

Ammonium nitrate	1.0 gram
Acid potassic phosphate	0.5 "
Magnesium sulfate	0.25 "
Iron sulfate	Trace
Cane sugar	3–5 grams
Water	100 cc

As a standard salt solution the above formula has been used without the sugar, the osmotic influence being neglected as of little consequence in comparison with the desirability of having equivalent salt constituents. The experiments with the so-called paraffin water resulted from a test of the value of a paraffin lining for flasks in which distilled water was to be used or kept on hand.

It is evident that so far as the fungi are culturable only pure cultures should be used for inoculation purposes. It is desirable, moreover, to avoid old cultures, and cultures which have been exposed to direct sunlight. When possible, I have used spores from cultures five to ten days old.

EXPERIMENTAL.

Table I will serve as the basis of some general comparisons with regard to the amount of germination on various nutrient media. In general a perfect food is the best stimulus for the germination of saprophytic forms, but in particular cases special stimuli are necessary. The standard organic solution has for germination purposes less strength than decoctions of plants. Generally speaking, the standard inorganic solution has about the value of sugar, except for the Mucoraceae. There is considerable difference, however, even with related species of fungi.

Of the purely saprophytic fungi studied, *Oedocephalum albidum* is the only one capable of germinating to considerable extent on pure water. This one exception is suggestive in that it is not necessarily a characteristic of saprophytic fungi that the spores do not contain within themselves the nourishment required for germination. Botrytis, though parasitic at times, would further

TABLE I.

PERCENTAGE OF GERMINATION.

In all cases the cultures were examined 15 hours after the spores were sown, then in most cases 24 and 48 hours later. When germination was not complete at the end of 15 hours there was very rarely germination. The results as given, however, are for the second or third observation.

Spores of	Culture media				
	Water	Bean decoction	Standard nutr. salt sol.	Standard inorg. sol.	Sugar solution
Aspergillus flavus	0†	100	100	75	75
Sterigmatocystis nigra	0	100	100	3–75	20±
Penicillium glaucum	0	100	100	20–50	1—
Œdocephalum albidum	100‡	100	100	50–75	100
Botrytis vulgaris	100	100	100	100	100
Monilia fructigena	75	100	100	100	100
Circinella umbellata	0	100	0	5	1—
Mucor erectus	?§	100	**	***	25±
Mucor racemosus	?§	100	100—	?§	80±
Mucor spinosus	0	100	100*	0	1—
Phycomyces nitens	0†	100	50–100	0	2–10
Chaetocladium Jonesii	0	100	100	0	80±
Coprinus fimetarius	0	5–10	0	0	0
Coprinus comatus	0	0	0	0	0
Coprinus micaceus	0	100	0	0	0
Boletus sp.	0	0	0	0	0
Ustilago perennans summer	1	100	...	...	...
Ustilago perennans autumn	50–70				100‡
Ustilago avenae summer	2–10	...	...	...	50
Ustilago avenae autumn	50				100‡
Ustilago striiformis	0	...	...	...	2±
Urocystis anemones	0	0	0	0	0
Uredo (P. graminis on wheat)	5	20	...	...	0
Uredo (P. graminis on rye)	50–95	20	...	...	50–100
Uromyces caryophillinus	100‡	75	...	...	100‡
Exoascus sp.	**	**	...	...	**
Ovularia primulina	100‡	75	...	...	75±

* Abnormal. ‡ Nearly. ** Budding.
† Usually. § Small. *** Some budding.

confirm this view. With the exception of *Coprinus micaceus*, most of the Hymenomycetes employed fail to germinate readily on bean decoction. Brefeld and others have determined that a large number of Coprini, Clavariae, and Tremellineae germinate well upon dung decoctions.

Glycerin, although slow in action,[12] often gives somewhat

[12] DUCLAUX,—: Annales de l'Institut Pasteur 3: 112. —.

TABLE II.

PERCENTAGE OF GERMINATION.

Spores of	Strength of solution %	Peptone	Strength of solution	Cane sugar	KH_2PO_4	NH_4NO_3	$MgSO_4$	Strength of solution	KNO_3
Aspergillus flavus	1	100	$\frac{n}{2}$	20	? †	0	15–30	$\frac{2n}{1}$	5–10
	0.1	100	$\frac{n}{10}$	20–75	? †	20	10–20	$\frac{n}{1}$	5–10
	0.01	50 ±	$\frac{n}{100}$	75–100	? †	70–100	5–10	$\frac{n}{2}$	5–10
	0.001	10–25	$\frac{n}{1000}$	50–75	? †	5–30	....	....	....
	....	....	$\frac{n}{10000}$	30–50	....	....	....	....	....
Sterigmatocystis nigra	1	100*	$\frac{n}{2}$	10–50	? †	0	? †		
	0.1	10‡	$\frac{n}{10}$	50–100	0	0	0		
	0.01	10	$\frac{n}{100}$	20–50	0	0	0		
	0.001	? †	$\frac{n}{1000}$	5	0	0			
			$\frac{n}{10000}$	5	0				

* Nearly, when spores are single. † Very sma—

‡ At edges of drop.

TABLE III.

PERCENTAGE OF GERMINATION IN GLYCERIN.

Strength of solution	Aspergillus flavus	Sterigmatocystis nigra	Penicillium glaucum	Œdocephalum albidum	Botrytis vulgaris	Ustilago avenae	Mucor spinosus
$\frac{n}{1}$	75	0	....	100*	75	50–90	0
$\frac{n}{2}$	100*	0	....	100	10–25	100*	0
$\frac{n}{10}$	75–100	0	....	100*	25	100*	0
$\frac{n}{20}$	....	....	20†	....	....	....	....

*Nearly. †After two days.

more germination than sugar, yet with Sterigmatocystis the case is reversed. In general, the difference in action has seemed to bear no particular relation to the physical properties of the substance, as for example its power of penetrating membranes.

Most of the smut forms gave good germination on bean decoction, although less on pure distilled water than has been reported by observers using ordinary tap water. *Uromyces caryophillinus* not only germinated less efficiently in bean decoction than in distilled water, but in beet decoction it failed entirely to germinate.

Of the three salts generally used in the standard nutrient salt solution, ammonium nitrate at a particular concentration gives abundant germination with *Aspergillus flavus*, but has no effect upon Sterigmatocystis. In general, the neutral salts give a greater stimulation than the one with acid properties. In this connection, reference should be made to the interesting results of Benecke.[13] He considers the presence of potassium absolutely necessary, and that without this metal no germination, or only traces of germination, can occur. Since his cultures were made in flasks, it is perhaps to be asked if he refers to germination (growth) visible to the unaided eye. Not only do some of the mold fungi germinate to considerable extent in solutions of

[13] BENECKE, W.: Die zur Ernährung der Schimmelpilze notwendigen Metalle. Jahrb. f. wiss. Bot. **28**: 487–530. 1895.

simple substances, but the form of Botrytis which I have used germinates within a few hours on large surfaces of pure distilled water. Moreover, the potassium compounds alone are only very slightly stimulating for germination, and I have found no marked increase in germination of Phycomyces and Penicillium by the addition of potassium nitrate to a solution of sugar. The above remarks are also partially applicable to the conclusions which Molisch[14] has drawn from his most interesting experiments with Aspergillus and Penicillium. He found no germination without magnesium, saying: "da ohne Magnesium nicht einmal ein Auskeimen der Pilzsporen stattfindet, und dieses Element weder durch die Elemente der alkalischen Erden (Ca, Str, Bar) noch durch die der Zinkgruppe vertreten werden kann." He also applied these results to all "lower" fungi, that is, apparently, to all culturable forms.

Pepsin and asparagin gave almost no germination with Sterigmatocystis. The latter substance had also very little effect on *Aspergillus flavus*, while the percentage of germination with the former substance was as high as ninety.

EFFECT OF SPECIAL STIMULI ON GERMINATION.

Under the head of special stimuli, or substances which are not normal sources of food supply, are also included, for convenience, certain carbon compounds, as well as the metallic salts and mineral acids.

In this connection an unexpected result was obtained with cultures of *Aspergillus flavus* on distilled water which had been standing in paraffin-lined flasks. Nearly all of the spores on the edge of the drop, or where single, germinated; and a large per cent. of germination occurred throughout the drop. In similar cultures Sterigmatocystis gave usually only 10 to 20 per cent. of germination. Penicillium and Phycomyces were not stimulated.

Ethyl alcohol affords a marked stimulus for the germination of aspergillus; germination being more nearly perfect on the edge of the hanging drop, but occurring markedly throughout.

[14] MOLISCH, H.: Die mineralische Nahrung der niederen Pilze. Sitzungsber. d. Kaisl. Akad. d. Wiss. zu Wien **103**[1]: 554–574.

TABLE IV.

PERCENTAGE OF GERMINATION.

Spores of	Stren'th of solution	Ethyl alcohol	Methyl alcohol	Stren'th of solution	Phenol	Strychnin	tren'th of olution	Ether	Stren'th of solution	Camphor	Petroleum	Vaseline	Clove oil
Aspergillus flavus	$\frac{n}{5}$	2	10–20	$\frac{n}{100}$	0	3–5	$\frac{n}{76}$	1–2	conc.	50	1–3	50–75 ‖	0
	$\frac{n}{50}$	3–5	20–25	$\frac{n}{1000}$	80	1–3	$\frac{n}{760}$	2–5	$\frac{1}{10}$	10	2	50–75 ‖	1
	$\frac{n}{500}$	75	10–50	$\frac{n}{10000}$	10–40	2–3	$\frac{n}{7600}$	1	$\frac{1}{100}$	10–25	....	50–75 ‖	1
	$\frac{n}{5000}$	50–70	10–75	$\frac{n}{100000}$	20–60	‡	$\frac{n}{76000}$	1	$\frac{1}{1000}$	5–10	....	50–75 ‖	0
	....	....	....	....	....	....	$\frac{n}{760000}$	10–25	....	....	....	.....	..
Sterigmatocystis nigra	....	....	....	....	....	....	....	....	conc.	30–70	....	....	0
	$\frac{n}{0}$	0	0	$\frac{n}{100}$	0	0	$\frac{n}{76}$	0	$\frac{1}{10}$	0	0	0	0
	$\frac{n}{50}$	0	0	$\frac{n}{1000}$	?†	0	$\frac{n}{760}$	0	$\frac{1}{100}$	0	§	5	0
	$\frac{n}{500}$	0*	1	$\frac{n}{10000}$	1–5	0	$\frac{n}{7600}$	0	$\frac{1}{1000}$	0	....	25–50 ‖	0
	$\frac{n}{5000}$	5–20	0	$\frac{n}{100000}$	0	0	$\frac{n}{70000}$	0	....	....	....	....	..
	....	....	....	....	....	....	$\frac{n}{760000}$	0	....	....	....	....	..

*Practically. †Small. ‡Considerable at edges. §Irregular. ‖When single.

Methyl alcohol is slower in action, and eventually less effective. Immersion of spores for short periods of time in injurious concentrations of ethyl alcohol, and subsequently sowing these spores in water cultures, afford no stimulus for germination.

The results with phenol, here only partially given, were unusually variable. More than with any other substance used, difficulty was here experienced from the evaporation and changes in form of the drop within the culture cell, which may partially account for the dissimilarity of results.

Experiments with chloroform were not made in drop culture, but an exposure of half an hour in a saturated atmosphere was found fatal to Aspergillus and Phycomyces, and without beneficial effect upon Sterigmatocystis.

Ether has proved of little consequence as a stimulus, except with Aspergillus at the lowest concentrations used. This was hardly to be expected in consideration of its action on the cell activities. It is to be noted that all of the above mentioned substances penetrate membranes immediately.[15]

At the end of fifteen hours there is an almost inappreciable stimulus with camphor, but its effect gradually increases to the third day.

With *Aspergillus flavus* germination in pure water was increased 10 to 20 per cent. when vaseline was used for cementing the covers to the rings.

The above experiments with Aspergillus on alcohol, camphor, strychnine, and vaseline were repeated in flask cultures. Again a concentration of $\frac{n}{500}$ alcohol gave more than 50 per cent. germination; but under these conditions camphor, strychnine, and vaseline gave uniformly little or no germination. This, as well as other experiments, suggested conditions in the hanging drop more favorable for germination than in flask culture.

Besides the results presented in Table V, an interesting fact is noted in connection with hydrochloric acid, as well as later

[15] OVERTON, E.: Ueber die osmotischen Eigenschaften der lebenden Pflanzen- und Tierzelle. Vierteljahrsch. d. Naturf. Ges. in Zurich 40: 1–43. 1895.

TABLE V.

PERCENTAGE OF GERMINATION AFTER THREE DAYS.

	Strength of solution	HCl	HNO_3	Acetic acid	Tartaric acid	Oxalic acid	$Cu(NO_3)_2$	Strength of solution %	$CuSO_4$	$MnCl + FeSO_4$	$ZnSO_4$
Aspergillus flavus	$\frac{n}{10}$	....	....	0	0	0	....	1.0	....	....	0
	$\frac{n}{100}$	0	0	15	5	0	0	0.1	0	3	1
	$\frac{n}{1000}$	1	5–25	20	10	1–5	0	0.01	0–40	10–20	1–5
	$\frac{n}{10000}$	20–30?*	1–2	15	25–50	1–5	?†	0.001	3–5	10–20	0
	$\frac{n}{100000}$	....	0	2–4	....	....	5–10	0.0001	25	30	....
	....	....	....	....	....	....	....	0.00001	3–10	....	....
Sterigmatocystis nigra	$\frac{n}{10}$	....	....	0	5	0	....	1.0	....	....	0
	$\frac{n}{100}$	1–3	0	10	1	25‡	0	0.1	0	0	0
	$\frac{n}{1000}$	3	1–3	10–20	1–5	2–10	0	0.01	0	0	0
	$\frac{n}{10000}$	5–10	0	20	2–3	3–5	0	0.001	15–30	?†	0
	$\frac{n}{100000}$	....	0	2–4	....	....	0	0.0001	0	?†	....
	....	....	....	....	....	....	....	0.00001	0	....	....

*On edges. †Very small. ‡Throughout; 100 per cent. on the edges.

for some other substances. The spores of *Aspergillus flavus* readily fly off from the surface of the drop, and such spores, falling on the cover glass beyond the limits of the medium, but of course moistened by the slight water of evaporation, gave at $\frac{n}{100}$ and at $\frac{n}{1000}$ a germination of 50 to 70 per cent.

The salts of the heavy metals have generally caused a slight increase in the germination of Aspergillus, but in no case have they acted very strongly.

A repetition of the experiments with nitric acid, $CuSO_4$, $Cu(NO_3)_2$ and $FeSO_4$ were also made in flask cultures at concentrations ranging from $\frac{n}{100}$ to $\frac{n}{100,000}$. Nitric acid of $\frac{n}{1000}$ and below has in every case given a small percentage of germination. The spores thus germinated show a considerable length of germ tube. Iron has had a similar but weaker effect. So far as could be ascertained from flask cultures, the copper compounds have at most caused a swelling of the spore, and in isolated cases the very slight protusion of a tube.

Although the stimulating action of the organic acids here included, as also the action of alcohol, may be a very different one from that of the inorganic acids, yet this stimulus of the organic acids is in no case a very remarkable one. As to whether or not these organic substances act as peculiar stimuli, or as food substances direct, there is evidently no good clue, for it is not yet possible to draw the line between those concentrations which should be considered stimulating or poisonous and those at which there may be an action merely as food. Clark's results previously mentioned have shown that alcohol at $\frac{n}{4}$ is the lowest concentration at which any inhibition of the germination of Aspergillus in nutrient media occurred.

In general, the action of the organic acids as food substances has been determined by means of the corresponding salts, and further than this we know very little about them. The stimulus given by $\frac{n}{100}$ or less of acetic acid to both fungi

deserves mention, although the percentage of germination is not great.

Oxalic acid stands quite alone as a substance stimulating Sterigmatocystis more than Aspergillus, in fact causing its maximum stimulus at a concentration which affords no germination with Aspergillus. This effect on Sterigmatocystis was so variant and marked that this acid is to be regarded as a peculiar stimulant for that plant.

THE INFLUENCE OF CERTAIN PHYSICAL STIMULI.

From some variations in results obtained it became evident that by the form of the drop and the amount of evaporation therefrom, or perhaps by some other physical force closely connected with these conditions, a considerable stimulus was given to germination. When the cultures of *Aspergillus flavus* were prepared at the same temperature at which they were to be incubated, with all possible precautions being observed as to purity of water and cleanliness of cover glasses, there was seldom more than a fraction of 1 per cent. of germination, provided the culture drop retained its original form and dimensions. In cases of some evident change of conditions within the culture, however, whether by slight dispersal of the drop or by a certain amount of evaporation, the percentage of germination was often greatly increased. In special cases the percentage of germination was as high as 90 after an incubation of fifteen hours, this maximum being reached particularly when the spores were free from each other and collected on the periphery of the drop next to the glass.

Many experiments were introduced with the hope of eliminating the single factors which might be involved and of accurately determining the cause of the stimulus. Unfortunately the matter is as yet very inconclusive.

If even very small amounts of some salts were present in the drop, these during evaporation would be concentrated at the periphery, especially at the edge in contact with the glass. This would hardly be sufficient, however, to account for the

germination observed, and such an occurrence of salts could only come from the well-cleaned glass surface.

As a check on the carefully prepared distilled water, cover glasses were moistened over a steam jet, and upon this condensation the spores were sown as before, the results also being parallel to those previously obtained.

The possible stimulus of rapid evaporation gave only negative results in the following experiment: Properly cleaned ground-glass slips were placed on benches (glass rings) in Petri dishes of distilled water. Strips of filter paper which had been soaked for days in acidulated water and then in distilled water were passed over the edges of the slips with the ends reaching into the water. A clear ground-glass surface of nearly an inch was left between the strips, and on this the spores were sown. This arrangement sufficed to keep a constant thin film of moisture over the glass from which evaporation might readily ensue. The covers of the Petri dishes were slightly raised, and these cultures were placed in a fairly dry atmosphere, in ordinary laboratory atmosphere, and in a moist chamber. After twenty-four hours there was from 10 to 20 per cent. of germination, and those cultures in the dry atmosphere gave perhaps less than the other two. Surface tension could hardly be considered a factor, for these fungi remained practically unchanged after a month on the surface of water in flask cultures.

To test the effect of contact and surface tension with the evaporation factor eliminated, well cleaned glass tubes were drawn out into a capillary end to be used as a culture cell. The tube was partially filled with water and the spores inserted. The water was then forced out until the spores reached capillary parts, when the larger end was also closed with water. Such cultures gave very slight germination after two days.

Attempts to increase the surface tension by means of small quantities of oil in the water gave only negative results. Massart[16] found surface tension productive of contact phenomena in

[16] MASSART, J.: La sensibilité tactile chez les organismes inférieures. Journ. de la soc. méd. et nat. de Bruxelles, December 1890.

bacteria, amoebae, flagellates, etc. Busgen[17] found that Botrytis reacts to surface tension by the formation of little bundles of branches perpendicular to the touched surface.

Besides the previously mentioned contact experiments, recourse was also had to the clinostat. By shaking, spores were submerged in flasks containing a small amount of distilled water. These flasks were then rotated horizontally so that there was constant movement of the spores and considerable contact with the glass surface. The results were negative. Likewise experiments made with a shock-imparting clinostat, and also with a combination of the rotation and shock, failed to give any positive results.

A small number of experiments was made to test the effect of evaporation caused by a lowering of the vapor tension. To effect this the cells were arranged in the Petri dishes as before. Water was used in the hanging drop above, except in control experiments, and below was placed the salt solution of various strengths. Over solutions of $MgSO_4$, varying in strength from $\frac{3}{2}n$ to $\frac{3}{8}n$, by far the best germination occurred over $\frac{4}{3}n$, where drying out was quite gradual.

According to Lesage,[18] who made a number of experiments to determine the dampness of the air in which spores would germinate best, the spores of Penicillium germinate well at all of the higher densities, but reached the lower limit between 82 and 84 per cent. humidity. Aspergillus germinates so well ordinarily at the higher humidities that the factor of evaporation seems of more significance.

The action of a change of concentration of the medium was tested in a small way. Spores of *Aspergillus flavus* were sown in Erlenmeyer flasks containing respectively 20, 10, and 5 per cent. KNO_3 in one series, and in another the same strengths of $MgSO_4$. After twenty-four hours about 5 to 10 per cent. of germination had occurred in the KNO_3 cultures and about 10

[17] BÜSGEN, M.: Ueber einige Eigenschaften der Keimlinge parasitischer Pilze. Bot. Zeit. **51**: 53–72. 1893.

[18] LESAGE, P.: Recherches expérimentales sur la germination des spores du *Penicillium glaucum*. Ann. d. sci. nat. Bot. **8**: 309–322. 1895.

per cent. in the $MgSO_4$. Water was then added to these cultures until the liquid was reduced tenfold in concentration. A second examination after the lapse of two days showed little or no increase of germination in the original 10 and 20 per cent. KNO_3, but an increase to about 25 per cent. in the 5 per cent. solution, and a similar increase in the 5 and 10 per cent. $MgSO_4$. In the culture containing 20 per cent. $MgSO_4$, the increased germination and the amount of growth was greater than in any other.

EFFECTS OF TEMPERATURE AND OXYGEN SUPPLY.

As previously mentioned, Heald found that fern spores kept at high temperature were incited to germination as by light, but a longer period of time was required and the response less uniform. In general I have found very little difference between the germination in water of fungi at 25° C. and at temperatures nearer the maximum. At 32° C. there is some increase in the germination of *Aspergillus flavus* in hanging drop, but not in flask cultures. The former might well be due to other conditions than to any augmentation from the higher temperature. On nutrient solution *Coprinus fimetarius* was slightly benefited by the same temperature. Such forms as *Coprinus comatus*, *C. micaceus*, *Boletus* sp., and *Urocystis anemones* could not be incited to germination at higher temperatures when no germination occurred at 25°. Botrytis and Phycomyces were both injured at the temperature of 32° C., Botrytis failing to germinate on water, and Phycomyces giving a slight growth at the bottom of the liquid. Changes of temperature from 28° to 32° C. and *vice versa* did not materially affect the germination of Aspergillus and Sterigmatocystis. After experiments of various kinds with the aecidiospores of *Puccinia graminis*, Eriksson and Henning[19] found that the best results were secured by placing the spores for a time on melting ice, and then sowing them on water. The next best results were obtained when the spores were soaked in water at 3° C. for three hours, and then sown at room temperature.

[19] ERIKSSON and HENNING: Die Getreideroste, 71. 1896. Stockholm.

The poorest results were secured when the fresh spores were directly sown at the room temperature. Cooling also had a favorable influence upon the uredospores. This excessive cooling is hardly a natural stimulus. It may be regarded perhaps as a substitution stimulus, able effectually to replace some other incitation of the natural environment.

A few experiments were made with reduced oxygen supply, mainly to see if slight variations in this regard would at all vary the results. With cultures at room temperature with an air pressure of 60^{mm} there was no noticeable effect on germination, either in water or in nutrient solution. At below 40^{mm} of air pressure there was marked retardation, but since such lower pressures were of little concern in these results, the matter was not carried farther.

INHIBITION OF GERMINATION BY NUTRIENT SOLUTIONS.

Various authors have made casual reference to the fact that ordinary nutrient solutions may injure the germination of certain fungi normally germinating in water alone. A thorough study of this matter should throw some light upon the conditions necessary for the penetration of the host plant by the parasite. As yet I have had opportunity to make but few experiments in this direction, but an accidental attempt to make a substitute for bean decoction by adding peptone to the standard nutrient salt solution gave some results of interest with certain smuts used. *Ustilago Avenae* and *U. perennans* gave but a small per cent. of germination on any solution containing 1 per cent. of a German preparation of peptone; and the pure peptone solution gave only 1 or 2 per cent. of germination. An American manufacture of peptone did not act as an inhibiting agent; but the pure peptone solution afforded no better germination than distilled water. On the other hand, Ustilago was not inhibited by either preparation of peptone.

Certain rust fungi also comport themselves somewhat peculiarly towards nutrient solutions, as seen in Table VI.

TABLE VI.

PERCENTAGE OF GERMINATION.

	Distilled H_2O	1% peptone	Beet decoction	Bean decoction	$\frac{n}{10}$ Sugar Solution	$\frac{n}{5}$ Glycerin	$\frac{n}{10}$ NH_4NO_3
Puccinia Helianthi (uredospores)	100—	20	25*		50	10*	0
Uromyces caryophillinus (uredospores)	100—	100—	0	75*	100—	100—	100—*

*Germ tubes very short and often ill-formed.

DeBary and others have noted an injurious effect of nutrient media upon the formation of zoospores in certain Peronosporeae. The effect is to suppress the amount of zoosporic germination, and to develop germ tubes instead. Wuthrich[20] found the same phenomenon characterizing the germination of *Phytophthora infestans* under the influence of small amounts of poisons. From experiments with *Plasmopara viticola*, I have found no germ tube development; but many nutrient media inhibit the germination of the species. Winogradski and Omeliansky[21] have determined that a number of organic compounds act even at considerable dilutions to hinder or prevent the normal action of the nitrite and nitrate bacteria, and often even to sterilize the solution in which it was attempted to grow these organisms. Among these inhibiting substances are peptone and other albuminoids, glycerin, salts of organic acids, and also ammonia.

We are at this time far from a rational conception of the most important problems concerning the relation between host and parasite. The resistance of species and varieties cannot be viewed merely from a histological standpoint, and so far as the problem is capable of solution, a complicated set of factors is to be expected. If peptone and other nutrient media may be injurious to the germination of certain fungi, not only the

[20] WUTHRICH, E.: Ueber die Einwirkung von Metallsalzen auf die Keimfähigkeit der Sporen einiger parasitischen Pilze. Inaugural-Dissertation, Berne, 1892.

[21] WINOGRADSKI und OMELIANSKY: Ueber den Einfluss der organischen Substanzen auf die Arbeit der nitrifizierenden Mikroben. Centrlb. f. Backt. u. Parasitenk. 5²:319–343, 371–387, 425–440. 1899.

poisonous excretions of plants, but all excretions may have their rôle to play regarding infection. At any rate, from the point of view of the fungus, a further study of chemotropism, of stimulants to germination, and of the inhibition of germination and growth by injurious substances cannot fail to lead us somewhat farther toward a knowledge of parasitic attack.

RESTING STAGES AND DRYING-OUT OF SPORES.

It is well known that seeds of certain phanerogams do not readily germinate on reaching maturity. From the researches of Weisner and others with rather peculiar phanerogams, it is seen that this resting period is not merely due to an absence of the best conditions, but that the element of time, as far as we know, is absolutely essential. Whether we may in some cases substitute for this element of time artificial changes of condition is mostly a matter of conjecture.

The same remarks will hold in a general way for the so-called resting stages of fungi. For the maturity of the spores of the Peronosporaćeae and many of the teleutospores of the Uredineae, as examples, a certain resting period is indispensable. From the cytological studies of Wager,[22] it would appear probable that in the case of *Cystopus candidus* the maturity of the oospores, so far as the external appearances are concerned, does not denote the maturity of the zoosporangium with reference to the full quota of nuclei as a basis for the formation of zoospores. It appears that a resting stage must intervene before the final divisions of the nuclei.

Teleutospores of *Puccinia graminis* germinate best when they have been subjected to all the changes of the winter months. Observations on the presence of a certain coloring matter in the walls of such spores led Dietel[23] to attribute to this certain properties for the prevention of the germination, and for protection against unfavorable conditions. DeBary[24] has found that the teleutospores of the previous harvest cannot be brought to germi-

[22] WAGER, H.: Reproduction of *Cystopus candidus*. Ann. Bot. **10**: 245–339.

[23] DIETEL, P.: Flora **74**: 151. 1891. [24] DEBARY, A.: l. c.

nation later than August of the following year, and the optimum germination occurs during the spring of the latter year. Eriksson and Henning[25] are of the opinion that a passage through the animal body will not act as a substitute for the dormant period. Such lines of work have not been systematically followed out, and even for the Uredineae, which are very variable in their disposition toward the resting period, the limitations are not sufficiently known. According to Kühn, Brefeld, and others, as previously mentioned, germination of certain smuts in water can only be induced after a period of rest, while immediate germination may result from the addition of food material. My own results also show that the per cent. of germination with *Ustilago Avenae* and *U. perennans* increases considerably from summer to autumn, even though the material is kept in dry condition.

In other experiments, *Sterigmatocystis nigra* kept dry in the laboratory for five years gave no germination, while material one and two years old gave good germination in nutrient media. This age of the material did not act as a stimulus to germination, however, since only a fraction of 1 per cent. germinated when sown on distilled water. After drying out for four days on slide at 25° C. neither *Aspergillus flavus*, *Penicillium glaucum*, nor *Sterigmatocystis nigra* showed any germination as tested by distilled water.

SUBMERGENCE OF SPORES.

Ordinarily the spores of such molds as *Aspergillus flavus* and *Sterigmatocystis nigra* float on the surface of solutions; and, depending upon the solution, they may or may not tend to collect at the line of attachment to the glass in drop cultures. The spores of Phycomyces and other Phycomycetes, as well as many Hymenomycetes, however, very readily sink beneath the surface. To test the capacity of Aspergillus for submerged germination, spores were sown in bean infusion between the parts of a strip of mica lightly separated. The mica was then dropped into a flask of bean decoction. After two days the removal and examination of the mica showed that all spores were germinated, those

[25] ERIKSSON and HENNING: op. c. 54.

in the middle, however, having developed a germ tube only about ten times the diameter of the spore, while those on the margin were growing luxuriantly. Under pressure submerged spores do not germinate.

Spores of *Aspergillus flavus* were also sown on a layer of agar beneath a considerable layer of the same material, the upper layer being poured on while the first was still soft. Germination readily resulted. Also spores in flask cultures of $\frac{n}{50}$ alcohol, submerged by shaking, germinated readily.

SOME PECULIARITIES OF GERMINATION VERSUS GROWTH.

The Hymenomycetes will doubtless form an interesting field for the study of germination relative to special stimuli. With studies which are yet merely preliminary I have secured only a single positive result of interest, but in many cases failures are likewise suggestive.

Brefeld, in his *Untersuchungen über Schimmelpilze* (part III), records that spores of Gasteromycetes and of Phallus (p. 174) particularly, as well as other members of the fleshy fungi, do not germinate under any conditions tried. On the other hand, *Coprinus stercorarius* (p. 14), *C. lagopus* (p. 99), and *C. ephemeroides* (p. 117) germinate well on any plant decoction, as likewise spores of Clavariae and Tremellinae (p. 181). *Coprinus ephemerus* (p. 109) is said to germinate once in perhaps ten trials. While I have not been able to germinate *Coprinus comatus* and *Boletus* sp., these forms have been studied only from fresh spores and from spores kept in the laboratory about two months. *Coprinus fimetarius* has given various small percentages of germination in different vegetable decoctions, but otherwise no germination. A species, which unfortunately was not determined while fresh, but later identified as *Coprinus micaceus*, has given little or no germination in all solutions containing no plant decoction. In bean and dung decoction the same material has furnished perfect germination. The question then of interest was to determine if there might exist in the bean decoction a substance stimulating germination but unnecessary for growth; in other words, if we may here

distinguish between a medium for germination and a growth medium. Spores of this fungus, caught with all possible sterilization precautions, were germinated on bean decoctions in flask cultures. About eight hours after the sowing, the liquid was filtered off in a sterile filter, and the collected mass of germinated spores was removed by a needle to a second filter. Here the spores were washed, and finally transferred to a flask of sterile water. In the latter they remained two days, the water being then poured off and the standard nutrient salt solution added. Growth proceeded gradually, and at the end of one month there was a thick mat covering the bottom of the flask, as if with a circular piece of canton flannel. With all of the precautions observed, and by a comparison of the mycelium, this must be taken to justify the belief that we may here deal with a case in which a medium failing to stimulate to germination may yet afford growth. Bean decoction, moreover, is a better growth medium, and it would seem that the stimulus to germination would be a food stimulus. Nevertheless, the addition of peptone to the standard nutrient salt solution also gave no germination, and if the stimulus is that of a food, it must be considered in the class of peculiar foods.

Some other results, scarcely comparable to the above, may, however, be mentioned at this place. Janczewski[26] has determined that *Ascobolus furfuraceus*, a plant growing normally on the dung of herbivorous animals, could only be prepared for germination by being passed through the digestive tract of such animals. White rabbits were the animals used in his experiments. We have here evidently a case in which the spore is immediately capable of germination provided it may be first acted upon chemically or otherwise, so that it is rendered capable of using the stimulus of the medium on which it normally grows.

DeBary[27] also found that *Onygena corvina*, growing on the feathers of birds of prey, seemed to require a particular stimulus

[26] JANCZEWSKI: Morphologische Untersuchungen über *Ascobolus furfuraceus*. Bot. Zeit. **29**: 257–262. 1870.

[27] DEBARY, A.: op. c. pp. 376–377.

of its normal environment in order that germination might be effected.

Coprinus comatus, *Boletus* sp., and a few other forms failed also to germinate on filtrates or decoctions of the soil in which the plants grew. The soil filtrate cultures were of course swarming with the bacteria which would thrive under such conditions. Equally futile have been the attempts to germinate these spores in the presence of alkaline substances, in a slightly acid medium, or in the presence of a reducing agent. Hartig[28] mentions the germination of *Merulius lacrimans* in the presence of ammonium and other alkaline compounds, after the failure of many other substances.

Brefeld[29] found that *Tilletia caries* fails to germinate in nutrient solution. If already germinated in water and then transferred to nutrient solution the death and bursting of the promycelium soon occurs.

DILUTION OF FOOD MATERIALS.

Concerning the minimum food supply necessary for more or less perfect germination there seem to be almost no references in the literature. The concentration, however, at which some substances begin to attract chemotropically, or practically this lower concentration, has been determined by Miyoshi.[30] For example, cane sugar at 0.01 per cent. attracted the hyphae of *Mucor stolonifer*, and ammonium nitrate attracted the same fungus at 0.05 per cent.; while meat extract of 0.005 per cent. was attractive for Saprolegnia. On the other hand, Eschenhagen[31] and others have found that germination and growth of the mold fungi may occur at very high concentrations.

Examining horizontal lines in table VII, these experiments are more or less comparable from the point of view of the concentrations of the medium. The standard nutrient salt solution

[28] HARTIG, R.: Der echte Hausschwamm.

[29] BREFELD, O.: Vgl. Unters. a. d. Gesammtgebeit der Mykologie. Part V, p. 152.

[30] MIYOSHE, M.: Ueber Chemotropismus der Pilze. Bot. Zeit. **52**: 1–28. 1894.

[31] ESCHENHAGEN, F.: Ueber den Einfluss von Lösungen verschiedener Concentration auf das Wachstum von Schimmelpilzen. Inaug.-Dissertation, Leipzig. 1889.

TABLE VII.

	Bean decoction			Standard nutr.-salt solution		Sugar solution		
	Strength of solution	Per cent. of germination	Remarks	Per cent. of germination	Remarks	Strength of solution	Per cent. of germination	Remarks
Aspergillus flavus						$\frac{n}{2}$	20	From 10–30%
	Standard	100		100		$\frac{n}{10}$	20	" " "
	$\frac{s}{10}$	100		100		$\frac{n}{100}$	75	Drops poor, spreading
	$\frac{s}{100}$	100*		65±		$\frac{n}{1000}$	10–50	Varying from middle to edges
	$\frac{s}{1000}$	60±	From 40–90% in different cultures	?‡	3% in middle of drop to 20% on edges	$\frac{n}{10000}$	5–20	" " "
	$\frac{s}{10000}$	20±	From 5–40% in different cultures	?‡	1% in middle of drop to 20% on edges			
	$\frac{s}{100000}$	?†		?†	Slight germination on edges only			
Sterigmatocystis nigra						$\frac{n}{2}$	5	Very few in middle
	Standard	100		100		$\frac{n}{10}$	20–75	Varied from center to edges
	$\frac{s}{10}$	100		100		$\frac{n}{100}$	10–50	" " "
	$\frac{s}{100}$	20±	Varied from 10–50% about 60%			$\frac{n}{1000}$	5–10	" " "
	$\frac{s}{1000}$	3±		2±		$\frac{n}{100000}$	5–10	" " "
	$\frac{s}{10000}$	0‖		0				
	$\frac{s}{100000}$	0		0				

*Nearly. †Very small. ‡Small. ‖Practically.

contains 5 per cent. of sugar, the beet decoction about 3 per cent., and the $\frac{n}{10}$ sugar solution 3.4 per cent. It is noticeable that with Aspergillus on bean decoction practically normal germination takes place as low as $\frac{s}{100}$ (standard solution diluted one

hundred times), and otherwise the coefficient of maximum germination is constantly above $\frac{s}{100}$. Parallel with the results cited above, flask cultures were made with the more variable Aspergillus. These cultures for the first two media showed at s and $\frac{s}{10}$ complete germination, at $\frac{s}{100}$ very good germination, at $\frac{s}{1000}$ a very small per cent., and at further dilutions none. Equivalent cultures on sugar solution are interesting, $\frac{n}{2}$ giving almost no germination; $\frac{n}{10}$, 25–40 per cent.; $\frac{n}{100}$ and $\frac{n}{1000}$ perhaps about 10 per cent.; and $\frac{n}{10000}$ a very small percentage. From this it will be seen that a tenfold dilution of the ordinary culture media affords perfect germination, and a dilution below one thousand times gives practically no germination except with very sensitive fungi.

INDIVIDUAL VARIATION OF SPORES.

No studies of importance seem to have been made upon the variation in capacity for germination of individual spores produced under similar conditions, or of spores from the same conidiophore or sporangium. Nevertheless, great individual differences exist, and in any medium which is not a strong stimulus for germination, varying percentages of perfect germination will invariably occur, whatever precautions of method may be observed.

CAPACITY FOR GERMINATION OF SPORES LONG INCUBATED ON WATER SURFACES.

Spores of *Aspergillus flavus* and *Sterigmatocystis nigra* were sown on distilled water in Erlenmeyer flasks. At the end of 10, 30, and 90 days some of these were transferred to bean decoction. Practically no germination had occurred on the water, and in nutrient solution of the new cultures these spores gave perfect germination. After 125 days, some germination had occurred among spores in masses, but this germination was by

no means general. The ungerminated spores of these fungi were entirely uninjured as to their capacity for germination after this period of incubation.

LENGTH OF LIFE OF GERMINATED SPORES IN WATER.

Spores of *Aspergillus flavus* and *Botrytis vulgaris* were sown in weak bean decoction, and after about eight hours, or when all had germinated, they were filtered and thoroughly washed. The masses of spores were then transferred to fresh distilled water and so preserved. The last sowing from these germinated spores was made after eighty days with Aspergillus, and at this time all were yet alive. With Botrytis, the last inoculation was made after forty days, with the same result. In the cultures in which these spores were tested, general growth alone was not depended upon, but individual germ tubes were located and growth from these directly observed.

LENGTH OF LIFE OF SPORES DRIED OUT AFTER GERMINATION.

Spores of Aspergillus and Botrytis were germinated as in the above experiments, and then dried on filter paper. With Botrytis no further growth could be secured from spores thus dried after twenty-four hours, thus in perfect agreement with the results of Nordhausen.[32] On the other hand, inoculations from the Aspergillus material and careful marking and observation of individual germinated spores gave a very general new growth after being dried out twenty days. After sixty-five days there was new growth from about half of those transferred, and after one hundred days there was no sign of growth from germinated spores. It would be interesting to compare further the behavior of parasitic and saprophytic forms in this respect. We know in a general way that the germ tubes of parasitic forms die quickly when dried. Indeed in an early paper by Hoffmann[33] it is stated that "Austrocknen im gekeimten Zustande,

[32] NORDHAUSEN, M.: Beiträge zur parisitärer Pilze. Jahrb. f. wiss. Bot. **33**: 1–46.

[33] HOFFMANN, H.: Untersuchungen über die Keimung der Pilzsporen. Jahrb. f. wiss. Bot. **2**: 267–337. 1860.

also Austrocknung des Keimfadens, für das Weiterwachsen absolut tödlich ist."

I am pleased to express my thanks to Professor Pfeffer for his kind advice and encouragement in the progress of this work completed in his laboratory at Leipsic.

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CURRENT LITERATURE.

BOOK REVIEWS.

Agricultural botany.[1]

THOSE practically interested in the cultivation of plants have felt the need of a text-book of botany adapted to their wants. They are interested in the science of botany only in so far as it applies to their operations, and the great mass of material in current text-books is of little value to them. It is noticeable, also, that as the science advances the authoritative text-books deal more and more with recondite matters, and are growing away from the needs of the practical cultivator. The appearance of a text-book definitely designed to meet the needs of this class, therefore, is very timely, especially when it is so excellent as the one written by Professor Percival. The author has had many years of experience in teaching and lecturing to students, practical farmers, and gardeners, and is in a position to select his material wisely. What is equally to the point, he is evidently in touch with what is best in the science of botany; and while captious criticism might point out omissions which destroy the philosophical perspective of the science, and deny to the reader any adequate conception of the plant kingdom as a whole, one cannot help but feel that this is an ideal demand which the constituency addressed have no time or inclination to realize. The author's style is that of a good teacher, the presentation being clear and logical.

This book is divided into eight parts. The first deals with the gross structures of seed plants, the topics being seeds, the root, the vegetative shoot, the leaf, the flower, the inflorescence, and the fruit. The account is clear and simple, and the terminology is not excessive, as is too often the case. The emphasis, of course, is laid upon the plants and structures most commonly met in cultivation. One of the excellent features of the book is the constant insistence upon practical demonstration and experiment, and these are suggested at every step. The second part deals with histology, and includes a brief but adequate and up-to-date presentation of the cell, cell division, tissues, and the anatomy of root, stem, and leaf.

The third part is devoted to plant physiology, and it is a pleasure to meet in such a book a good presentation of the formal aspects of the subject. Perhaps they are too formal, but the experiments are numerous and usually good, and well adapted to the constituency. The only criticism which seems

[1] PERCIVAL, JOHN: Agricultural Botany, theoretical and practical. 8vo. pp. xiii + 798, illustrated. New York: Henry Holt & Co. 1900. $2.50.

worth mentioning is that little idea is given of the plant as an irritable organism, irritability being scarcely alluded to except in connection with movements. The subjects treated are the chemical composition of plants, osmosis, absorption of water, transpiration, absorption of food materials, photosynthesis, formation of proteids, translocation and storage of foods, enzymes, respiration, growth, reproduction, cultivated plants and their origin, and plant breeding. Under the head of sexual reproduction of seed plants the author in the main steers clear of the usual misleading terminology, but evidently finds it impossible to make clear the real situation without more training than the book demands.

The fourth part has to do with the "classification and special botany of farm crops." After a general discussion of the classification of plants, in which the emphasis is naturally laid upon seed plants, the author selects for special presentation the following families: Cannabaceae, Chenopodiaceae, Cruciferae, Rosaceae, Leguminosae, Umbelliferae, Solanaceae, Compositae, and Gramineae, with special chapters on cultivated and wild oats, cultivated barleys, rye, wheats, grasses, and clovers. The fifth part discusses the weeds of the farm. A general discussion of the injurious effects of weeds, their duration, their habit of growth, how they spread, and their extermination, is followed by an account of special weeds.

The sixth part presents the subject of farm seeds, the purity, germination capacity, germination energy, weight, form, color, etc., of seeds being discussed. The seventh part considers fungi chiefly in relation to some common diseases of plants. After a presentation of the structure and habits of fungi in general, the different diseases which they produce in farm crops are discussed. The last part is devoted to a consideration of bacteria. The morphology and reproduction of bacteria are first presented, and afterwards their work in lactic, butyric, and acetic fermentations, and in putrefaction, nitrification, denitrification, fixation of free nitrogen, and diseases of animals.

It will be observed that the scope of the book is broad, and that it includes the subjects of special interest to cultivators of plants. It certainly deserves to be received eagerly by agricultural schools and those engaged in agricultural pursuits.— J. M. C.

A botanical dictionary.

THE making of a good dictionary, even though limited to the special vocabulary of a single science, is not the easy task a novice might imagine. It is fortunate, therefore, that the task was undertaken by so competent a person as Mr. B. Daydon Jackson, who, if we may judge by his works, delights in painstaking labor of a kind that is intolerable drudgery to most men. He fully realizes the difficulties of the present task and the meager appreciation it is likely to receive, for he aptly quotes Dr. Johnson: "Every other author may aspire to praise, the lexicographer can only hope to escape reproach."

It will be only just, therefore, to express at once our hearty commendation of the work which Mr. Jackson has done, and to say that the glossary, as he modestly calls it,[2] is not only by far the largest and most comprehensive botanical dictionary in the English language, but by far the best. Concise definitions, brief derivations, and the accents are given for almost 15,000 words, which is about three times the number in Crozier's hastily compiled dictionary, issued a few years ago in this country. The only English botanical dictionaries are long since out of date and practically useless.

Mr. Jackson has succeeded remarkably well in traversing the whole range of our terminology. Even very new words have not escaped him, for he includes such terms as *edaphic*, *tropophyte*, *geophyte*, *coenocentrum*, *compound oosphere*, etc. Most of the definitions are concise and good ; some, however, are incomplete, *e. g.*, *tree*, *xerophyte ;* some are careless or ambiguous, *e. g.*, *coenocentrum*, *mycorhiza* (misspelled mycorrhiza), *geophyte ;* and some are antiquated or erroneous, *e. g.*, *archesporial cells*, *chlorovaporization*, *oogenesis*, *fertilization*, *sperm cell*, etc. The accent given does not always coincide with lexicons, *e. g.*, *medúllary* and *eláter*. In the former case it does not coincide with usage in this country though the author says medúllary is the usage in England. And if usage even permits eláter, it violates all rules of quantity.

Part, perhaps a large part, of the faults are due to the extreme condensation of the definitions. This might have been avoided, without making the volume of inconvenient size, by dispensing with a number of words derived from Crozier's dictionary, which, as inquiry and search indicate, neither have nor have had botanical use in literature, *e. g.*, *gusset*, *ensate*, *hydroid*, *polydelphous*, *secondine*, etc. Greater fullness of the definitions might also have been compensated for by using thinner paper, instead of the thick and stiff stock, which, together with the stiff binding (entirely unfit for such a reference book), prevents the book from opening comfortably or lying open. But blemishes such as these, the more noticeable because so easily avoidable, may well be overlooked in view of the good qualities, too many to enumerate, which distinguish this book from its predecessors. Every laboratory needs a copy on its shelves.—C. R. B.

MINOR NOTICES.

THE FOURTH PART of the "Catalogue of Welwitsch's African plants," by W. P. Hiern, and published by the British Museum, has just appeared, including Lentibulariaceæ to Ceratophylleæ. The occasion of the publication was stated in the review of the first part, published in the GAZETTE (23 : 210. 1897). The present part contains some important families, as Acanthaceae, Verbenaceae, Labiatae, Euphorbiaceae, etc. Approximately ninety

[2] JACKSON, BENJAMIN DAYDON : A glossary of botanic terms, with their derivation and accent. 12mo. pp. xii + 327. London : Duckworth & Co. Philadelphia : J. B. Lippincott Co. 1900.

new species are described, about one third of which are Labiatae; and to the same family the single new genus (*Symphostemon*) belongs.—J. M. C.

THE SERIES OF PUBLICATIONS by de Wildeman and Durand, setting forth the flora of Congo, has now reached the completion of the second fascicle.[3] In this fascicle it is stated that the number of spermatophytes, which a year ago was estimated to reach 1500, has now reached 2000. The fascicle deals with collections made by Belgian explorers, officers, and missionaries, and contains the descriptions of about twenty-five new species.—J. M. C.

THE FIRST VOLUME of Wiesner's *Die Rohstoffe des Pflanzenreiches* is now completed by the publication of the fifth part.[4] The subject of yeasts is completed; products of algæ and lichens are elaborated by Dr. F. Krasser (31 pp.), of which the most important is agar, and carrageen or "Irish moss," dye-yielding lichens, "Iceland moss," and "reindeer moss." Dr. W. Figdor treats the galls (27 pp.), and Dr. F. von Höhnel the barks (96 pp.), with which important section the volume concludes.—C. R. B.

DR. H. A. HARDING, of the N. Y. Agricultural Experiment Station at Geneva, has found that the black rot of cabbage and allied plants is a widespread disease in Europe,[5] which has been overlooked by continental pathologists. He observed it in the vicinity of Versailles, Bern, Zürich, Karlsruhe, Bonn, Harlem, Fulda, Halle a. S., Berlin, Kiel and Slagelse in the course of some months of travel in France, Germany, Switzerland, Belgium, Holland, and Denmark in the autumn of 1898. Only in Switzerland and Denmark did the disease seem to be of economic importance.—C. R. B.

THE *Proceedings of the Indiana Academy of Science* for 1889, just received, contains the following botanical papers: "Contributions to the flora of Indiana," and "Some unrecognized forms of native trees" (*Asimina triloba*, *Juglans nigra*, *Liriodendron Tulipifera*, and *Disopyros Virginiana*), by STANLEY COULTER; "A list of plants collected at Cedar, Shriner, and Round Lakes," by C. C. DEAM; "The resin ducts and strengthening cells of Abies and Picea (illustrated), by HERMAN B. DORNER; "A proteolytic enzyme of yeast," and "Saccharomyces anomalus," by KATHERINE E. GOLDEN; "Some problems in Corallorhiza," and "The disappearance of *Sedum ternatum*," by M. B. THOMAS.—J. M. C.

[3] WILDEMAN, EM. DE ET DURAND, TH.: Annales du Musée du Congo. Botanique, série II. Contributions a la flore du Congo. Tome I. Fasc. 2. (2me Partie.) 4to. pp. 49–83. Bruxelles: Charles Vande Weghe. July 1900.

[4] WIESNER, JULIUS: Die Rohstoffe des Pflanzenreiches. Versuch einer technischen Rohstofflehre des Pflanzenreiches. Ed. 2. Lief. 5. pp. 641–795, *figs. 123–153*. Leipzig: Wm. Engelmann. 1900.

[5] Die schwarze Fäulniss des Kohls und verwandter Pflanzen, eine in Europa weit verbreitete bakterielle Pflanzenkrankheit. Centralbl. f. Bakt. II. **6**: 305–313. *pl. 2* and *map*. 1900.

NOTES FOR STUDENTS.

IN THE *Gardener's Chronicle* for November 10 last, Mr. W. G. Smith figures a curious malformation on the pileus of *Agaricus albus*, recently collected and now in the British Museum. On the lamellar surface of the obconical pileus there are five smaller pilei, each raised on a short stipe, arising almost in the same plane, midway from stipe to margin.—C. R. B.

CZAPEK's recent paper[6] upon the sensitiveness of the root tip to geotropic influence will be read with exceptional interest by all who have attempted to repeat, for class demonstration or otherwise, his ingenious experiments with bent glass caps. There appeared last year, in Russian, a paper by Wachtel[7] containing a mass of experimental evidence which the writer believed to disprove Czapek's thesis entirely. Wachtel failed to obtain the curvatures described by Czapek for capped roots, and he obtained other curvatures which seemed to prove the absence of any localization of the sensitive region in such organs. Czapek has retraversed the whole disputed ground in his usual careful manner. He was able to reproduce all of Wachtel's results and shows that they were due to imperfect manipulation in the preparation of the glass caps. The walls of Wachtel's capillary tubes were too thin, thus bringing about either a narrowing of the bore at the angle, or the production of an angle too blunt for the desired purpose. Either of these conditions prevents the success of the experiment. The present article contains a translation into German of a good part of Wachtel's paper, with critical remarks, and a discussion of the difficulties of manipulation, including a very detailed account of Czapek's own methods.

There is also added a new experimental proof of the fact that only the formative region of the root tip is sensitive to the earth's gravitation. Briefly, this is as follows: Vertically placed roots are allowed to grow into right-angled caps in the usual way; then the caps are removed, the seedlings placed upon the revolving klinostat, and their behavior is observed. Within a few hours a bending becomes evident, the after effect of the stimulus received by the stationary horizontal tip while still within the cap. Various positions of the roots were tried and all point to the same conclusion. The new method is even more elegant than the older one, and in itself amounts to a proof of Darwin's hypothesis of the localization of the sensitive region.—BURTON EDWARD LIVINGSTON.

[6] CZAPEK, FRIEDRICH: Ueber den Nachweis der geotropischen Sensibilität der Wurzelspitze. Jahrbücher für wiss. Bot. **35**: 313. 1900.

[7] WACHTEL, M.: Zur Frage über den Geotropismus der Wurzeln. Berichte der neurussischen Gesellschaft der Naturforscher in Odessa **23**: 48. 1899.

NEWS.

DR. A. NESTLER has been appointed assistant professor in the German University at Prag.

DR. R. HEGLER, *privat-docent* in the University of Rostock, died at Stuttgart on September 28.

SIR JOSEPH HOOKER has been elected one of the foreign associates of the French Academy of Sciences, Institute of France.—*Gard. Chron.*

THE SECOND MEETING of the naturalists of the central states was held at Chicago, on December 27 and 28, in the biological buildings of the University of Chicago. There was a good attendance of both zoologists and botanists. Among the latter were Messrs. Ramaley of Colorado, Pound of Nebraska, Thom of Missouri, Shimek of Iowa, MacMillan of Minnesota, Timberlake, Densmore, and Smith of Wisconsin, Millspaugh, Hill, Caldwell and Holferty of Illinois, Mottier and King of Indiana, Grover of Ohio, Copeland of West Virginia, and Jeffrey of Toronto. The visitors, together with the botanical staff of the University of Chicago, and the ten or twelve graduate students who were still at the University during the holidays, made up a satisfactory botanical attendance. The papers were numerous enough to demand the division on Friday afternoon into botanical and zoological sections. The botanical papers were as follows: H. C. COWLES, H. N. WHITFORD, and C. C. ADAMS: The relation of base-leveling to specific differentiation. A symposium, treated from the standpoint of both plants and animals. B. M. DAVIS: Coenogametes. H. G. TIMBERLAKE: Swarmspore formation in Hydrodictyon. G. H. SHULL: Variation in the florets and bracts of *Aster puniceus* Linn. H. N. WHITFORD: The genetic development of the forests of northern Michigan and a consideration of the factors controlling the distribution of coniferous forests. E. C. JEFFREY: An anatomical classification of vascular plants. H. C. COWLES: Application of the quantitative method to the dynamical study of plant societies. R. B. THOMSON: North American Chalazogams. O. W. CALDWELL: The use of color photography in demonstration work. J. H. FAULL: Some interesting features in the anatomy of the Osmundaceae. E. B. COPELAND: Stomata of some Liliaceae. The success of this meeting justifies the expectation that a society of the naturalists of the upper Mississippi valley meeting at this time of year, can be made successful. A third meeting, at which a formal organization may be effected, will be held in Chicago in December 1901.